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REPORT

COLOUR TELEVISION DISPLAYS:
Error diagrams for evaluating the reproduced chromaticities of some test colours

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COLOUR TELEVISION DISPLAYS: ERROR DIAGRAMS FOR EVALUATING THE REPRODUCED CHROMATICITIES OF SOME TEST COLOURS

E.W. Taylor, M.A.(Cantab.), C.Eng., M.I.E.E.

Summary

Sets of charts or 'error diagrams' are provided, which enable the errors in the reproduction of each of seventeen test colours to be obtained, when this reproduction is effected by a colour television display in which one or more phosphors have chromaticities differing from the specified System I values. The error in test-colour reproduction is given by the vector sum of the three errors obtained by considering the effect of each display phosphor by itself. A statistical assessment of the accuracy of the method over the range of phosphor chromaticities covered by the error diagrams is given, showing that the test-colour chromaticity co-ordinate values obtained by the use of the charts are likely to be accurate to within a tolerance given, at worst, by 13% of the scalar sum of the errors in test-colour reproduction found for the individual phosphors.

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COLOUR TELEVISION DISPLAYS: ERROR DIAGRAMS FOR EVALUATING THE REPRODUCED CHROMATICITIES OF SOME TEST COLOURS

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1. Introduction

The colour-analysis characteristics of colour cameras (and other picture-originating equipment) are based on the assumptions that the colour display will contain the set of phosphors whose displayed chromaticities are as specified* (Table 1) for the 625-line System I transmissions,[1] and that the display white point has the chromaticity of Illuminant D_{65} (u = 0·1978, v = 0·3122).

Table 1

Phosphor	Chromaticity Co-ordinates u	v
Red	0·451	0·349
Green	0·121	0·374
Blue	0·175	0·105

Primary chromaticities for System I phosphors

A theoretically ideal colour camera, viewing a certain test colour in Illuminant D_{65}, would generate three 'colour-separation signals' of such magnitudes that this System I display would adopt the same chromaticity as the original test colour when supplied with these signals. This theoretically ideal situation is not normally realized in present-day practice, and errors occur in the magnitudes of the colour-separation signals obtained from practical picture-originating equipment, in the chromaticities of the phosphors in a practical colour display, and in parameters of the intermediate signal-processing equipment. It is usual to express the errors arising in one part of the television system by calculating the resulting system performance on the assumption that all other components of the system are perfect: in the present context the assumption is therefore made that the excitation of each phosphor in the colour display is brought about by a colour-separation signal of the theoretically ideal magnitude for the test-colour chromaticity under consideration.

The colorimetric error of reproduction of a certain test colour is a vector quantity whose magnitude and direction is given by the line joining the ideal and erroneous

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*In terms of the 1960 CIE uniform chromaticity scale of units (u, v)[2a]

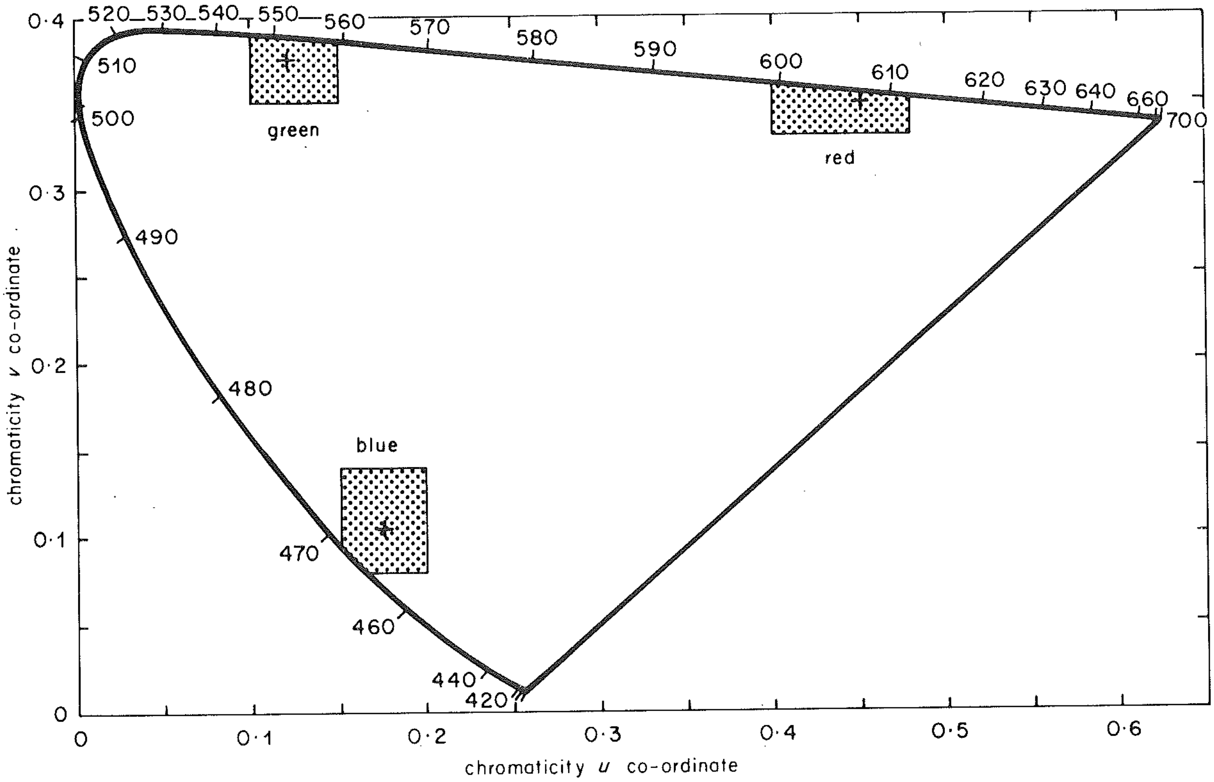

Fig. 1 - Range of phosphor chromaticities covered by error diagrams

+ System I chromaticity

chromaticities as plotted on the (u, v) diagram. In the present case the calculation of such a colorimetric error, given the chromaticities of the phosphors in the display is rather tedious since it involves the derivation of a 3 x 3 matrix[2b,3] and is best attempted using a computer. A method has been developed[4] in which, for each test colour, three 'chromaticity error diagrams' are provided (one for each phosphor in the display). Each error diagram enables the vector magnitude of the error in the reproduced chromaticity of the test colour, due to the departure of one of the three phosphor chromaticities from the System I value, to be determined graphically. The total error in reproduction is then given by the (vector) sum of the three individual chromaticity error vectors (see section 2.2.1). The range of phosphor chromaticities (Fig. 1) covered by the error diagrams which form the subject of this report has been chosen to include values that are likely to be encountered in practical colour displays, consistent with the desirability of providing as open an error-unit scale (see section 2.1) as possible. This approach has precluded the inclusion of the chromaticities of laser emissions which could in principle be used in colour displays.

The ideal chromaticities and colour separation signal magnitudes of the test colours for which chromaticity error diagrams have been derived are shown in Table 2 and the ideal chromaticities are also shown graphically in Fig. 2. The CIE test colours numbers 1–8 are those specified[5] for calculation of the general colour rendering index as proposed for specifying the colour rendering properties of light sources. The BBC test colours 9 – 16 are a sub-set of desaturated colours taken from a set of 26 test colours[6] used in the assessment of colour camera performance, while BBC test colour 17 is a skin tone from this same set of colours.

Some inaccuracy results from the use of this graphical method of determining colour display performance. Inaccuracies occur because the error diagram for any one display phosphor is derived on the assumption that the other two display phosphors have the correct System I chromaticities, and this assumption is clearly not strictly true when the chromaticities of more than one display phosphor differ from the System I values, as is usually the case. A numerical estimate of this loss of accuracy is made in section 2.2.2.

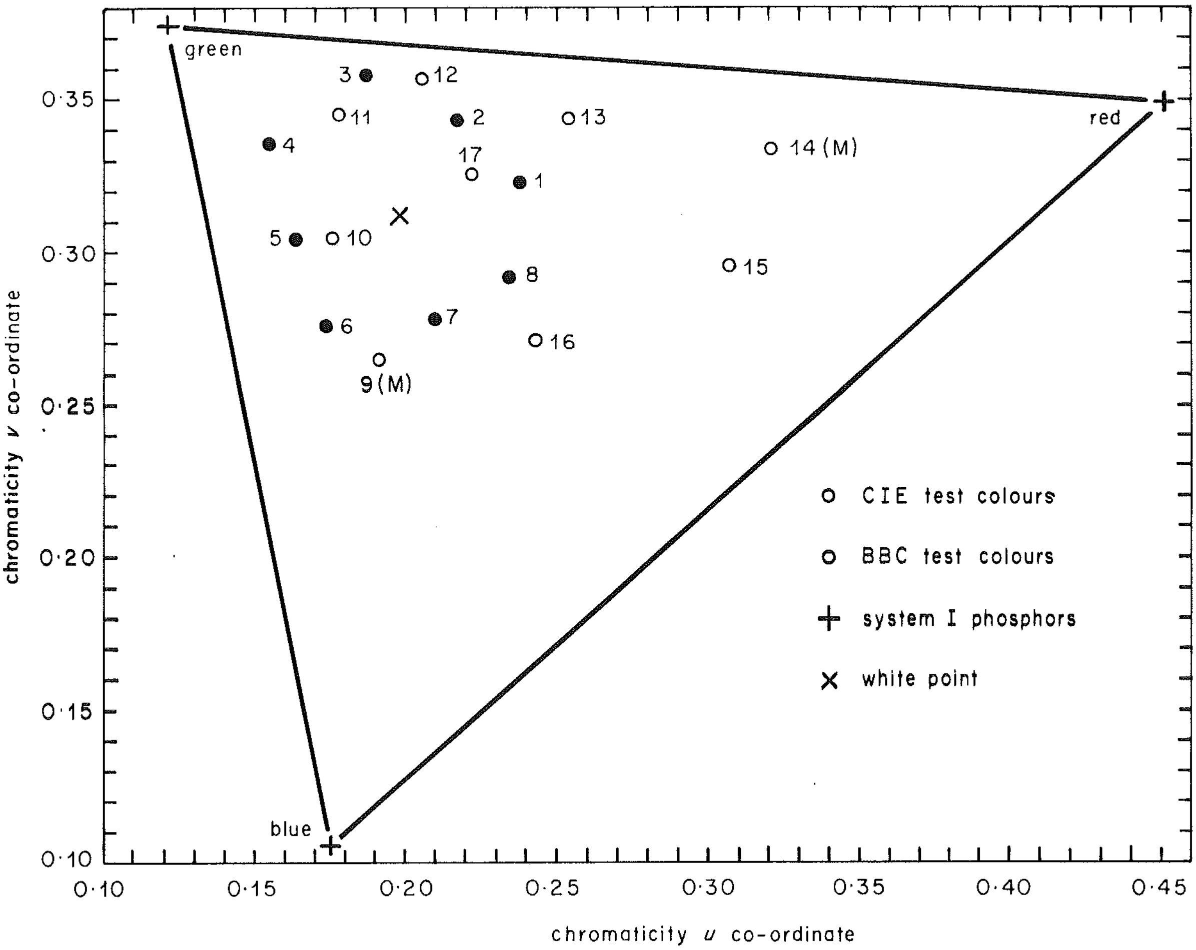

Fig. 2 - Test colour chromaticities

Table 2

Test Colour	Chromaticity Co-ordinates		Relative Luminance (White = 1·0000)	Colour Separation Signals (% relative to white)		
	u	*v*		Red	Green	Blue
CIE 1	0·2383	0·3230	0·2977	47·83	24·93	21·65
CIE 2	0·2173	0·3429	0·2891	36·81	28·22	11·19
CIE 3	0·1872	0·3580	0·3046	25·98	34·41	5·22
CIE 4	0·1552	0·3361	0·2950	11·32	36·43	17·29
CIE 5	0·1641	0·3041	0·3085	14·30	35·35	37·70
CIE 6	0·1738	0·2757	0·2981	17·33	31·01	56·87
CIE 7	0·2102	0·2784	0·2938	35·81	25·06	52·28
CIE 8	0·2335	0·2921	0·3135	49·98	24·26	43·92
BBC 9 (M)*	0·1910	0·2650	0·3000	26·41	27·56	65·47
BBC 10	0·1756	0·3049	0·5675	36·75	61·95	67·39
BBC 11	0·1771	0·3446	0·4491	31·69	51·72	18·30
BBC 12	0·2051	0·3572	0·5979	65·49	63·03	9·72
BBC 13	0·2541	0·3436	0·4586	82·20	37·58	15·10
BBC 14 (M)*	0·3210	0·3340	0·1712	47·70	8·55	7·10
BBC 15	0·3068	0·2959	0·1769	49·30	7·42	21·35
BBC 16	0·2427	0·2709	0·3478	62·88	22·73	67·19
BBC 17	0·2221	0·3256	0·4404	59·90	40·42	30·67

Details of Test Colours

*See Section 3

Changes in the chromaticities of the phosphors in a colour display affect the relative luminance of the reproduced scene colour as well as its chromaticity, and it is possible to derive a set of 'luminance error diagrams' for each test colour from which the error in reproduced luminance caused by a departure of the phsophor chromaticities from the System I values may be determined. It is, however, generally true that in such circumstances the error in reproduced luminance is of minor importance compared with the corresponding chromaticity error, and it follows that if the chromaticity error for a particular test colour is found to be acceptable, then the luminance error is not likely to be significant. No luminance error diagrams are therefore included in this report.

2. Description and use of the chromaticity error diagrams

2.1 Description

Three chromaticity error diagrams (one corresponding to each display phosphor) are required for the complete determination of the error in reproduced chromaticity of any one test colour. Each diagram contains two co-ordinate grids, the 'error-unit' grid and the 'phosphor chromaticity' grid.

The error-unit grid is an enlargement of the chromaticity diagram (Fig. 1) in the region of the co-ordinates of the test colour, re-scaled in 'error-units' of *u* and *v* so that the origin is at the point corresponding to the ideal chromaticity of the test colour.

The phosphor chromaticity grid, which is superimposed on the error-unit grid, is scaled in terms of the chromaticity of the phosphor under consideration, and is so arranged that a point on the error diagram defined by a particular pair of phosphor chromaticity co-ordinates also represents the error in the reproduced chromaticity of the test colour as defined by the error-unit co-ordinates. The line joining the origin of the error-unit grid to the above described point therefore represents, in (*u*, *v*) units as read off from the error-unit grid, the magnitude and direction of the error in reproduced chromaticity. Since no such error would be present if the phosphor under consideration had its appropriate System I chromaticity, the point defined as this chromaticity by the phosphor chromaticity grid always coincides with the origin of the error-unit grid.

In general, the phosphor chromaticity grid in non-orthogonal and the standardized method* of labelling the phosphor chromaticity grid lines sometimes reduces the clarity of distinguishing its u– and v–axes. A small subsidiary diagram is therefore provided which indicates the orientation of the axes of the phosphor chromaticity grid, the arrows pointing in the directions of increasing u– and v–values. Lines of constant u run approximately** in the indicated v–axis direction, and conversely for lines of constant v, as in a conventional plot.

chromaticity. In very general terms it might be expected[4] that the magnitude of the reliability vector would be related to the magnitudes of the individual error vectors obtained from the three chromaticity error diagrams. Calculations have therefore been made of the ratio (S) of the reliability-vector and corresponding overall error-vector magnitudes.* Thus, if

$$C = \left[(E_{u\mathrm{T}} - E_{u\mathrm{D}})^2 + (E_{v\mathrm{T}} - E_{v\mathrm{D}})^2\right]^{1/2} \tag{4}$$

where C is the magnitude of the reliability vector, the subscript D indicates a co-ordinate describing the directly-calculated total error vector, and all other symbols and subscripts are as defined for equation 1 and 2, then the ratio S is given by

$$S = \frac{C}{(E_{uR}^2 + E_{vR}^2)^{1/2} + (E_{uG}^2 + E_{vG}^2)^{1/2} + (E_{uB}^2 + E_{vB}^2)^{1/2}} \tag{5}$$

2.2 Method of use

2.2.1 Outline of procedure

The total error in the reproduced chromaticity of a certain test colour, due to the use of display phosphors of given chromaticity, is given by the sum of the error vectors indicated by each chromaticity error diagram for the test colour concerned. Thus

$$E_{u\mathrm{T}} = E_{u\mathrm{R}} + E_{u\mathrm{G}} + E_{u\mathrm{B}} \tag{1}$$

and

$$E_{v\mathrm{T}} = E_{v\mathrm{R}} + E_{v\mathrm{G}} + E_{v\mathrm{B}} \tag{2}$$

where E_u and E_v are the u and v error co-ordinates describing the chromaticity error vectors;

the subscripts R, G and B indicate that the co-ordinates are derived from the chromaticity error diagrams corresponding to the red, green and blue phosphors respectively.

and the subscript T indicates a co-ordinate describing the total error vector.

The total error magnitude (E_T) is therefore given by:

$$E_\mathrm{T} = (E_{u\mathrm{T}}^2 + E_{v\mathrm{T}}^2)^{1/2} \tag{3}$$

2.2.2. Estimate of the loss of accuracy involved in use of the graphical method

The chromaticity error diagram for any one test colour and display phosphor is derived on the assumption that the other two display phosphors have the correct System I chromaticities. In cases where more than one display phosphor chromaticity differs from the System I value, the use of the graphical method will therefore give only an approximation to the true colorimetric error reproduction of the test colour. The degree of accuracy of the graphical method may be expressed in terms of a 'reliability vector' representing the departure of the reproduced test-colour chromaticity (as predicted from the error diagrams) from the directly-calculated reproduced

Values of the ratio S have been calculated for each of the 17 test colours and for the combinations of phosphor chromaticity shown in Fig. 3. Four groups of phosphor chromaticity values were used, each such 'phosphor group' containing three red, three green and three blue phosphor chromaticities. Two of these groups (numbers 1 and 2) consisted of chromaticity values (shown by ● and ▲ in Fig. 3) on the boundaries of the ranges of values covered by the chromaticity error diagrams. The other two groups (numbers 3 and 4) contained chromaticity values (shown by ○ and △ in Fig. 3), chosen to be 0·01 units of u and v within these boundaries except where this criterion gave too great a relaxation in the stringency of the test. Within each phsophor group all possible combinations of red, green and blue phosphor were considered: thus 27 different tests were performed for each test colour, and hence 459 tests over all test colours.** The values of the ratio S calculated for each phosphor group were divided into 'value groups' of width 0·01 units and centred***on the values 0·01, 0·02, . . . 0·14 and a cumulative arithmetic probability plot was made in each case (Fig. 4). It can be seen that in each case the spread of the ratio values among the value groups approximates to a normal distribution (such a distribution would give a straight-line probability plot). Furthermore, a significant difference exists between the 'boundary' and 'inner' categories of phosphor group described above, although the difference between the two phosphor groups in each category is not significant.

In situations where numerical data is subject to random error, it is common practice only to regard as being significant those numerical differences that have less than a 5% probability of occuring purely by chance. In the present case this criterion may be used to define the degree of accuracy of the prediction of the shift of reproduced test colour. In the case of the boundary category of phosphor group, there is a less than 5% probability that the ratio value will fall in a value group higher than 0·13 (Fig. 4), while for the inner category of phosphor group the corresponding value group is 0·08. Assuming that these distributions of ratio values hold for all combinations of phosphor chromaticities met with in practice, within the categories discussed above, either of these limiting ratio values ($S_{5\%}$) is, from Equation 5, related to the magnitude of the corresponding reliability vector likely to be exceeded with less than 5% probability ($C_{5\%}$) by the expression

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*The method used represents the necessary compromise between clarity of expression and complexity of programming.

**Since such lines are not necessarily parallel.

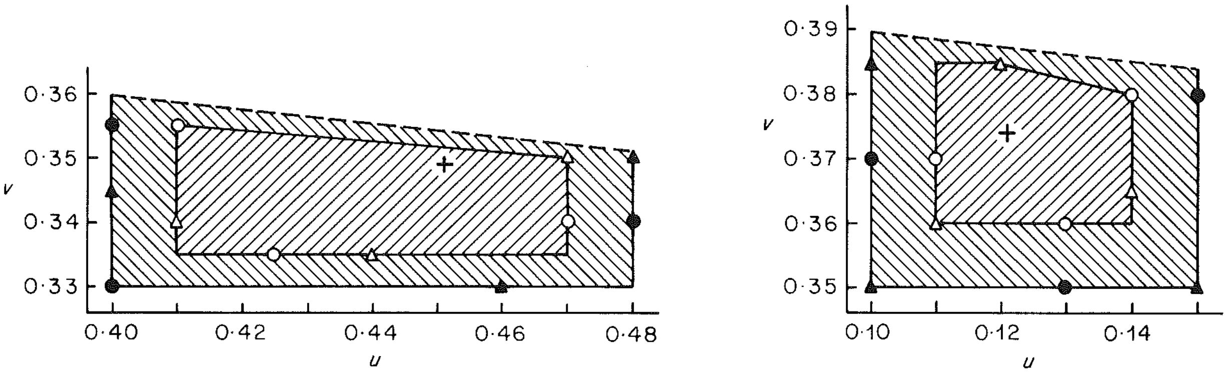
* Some of the symbols used in Equations 4–6 differ from the corresponding symbols in reference 4.

** The use of the chromaticity error diagrams was modelled in a computer programme.

*** The value group of nominal centre value 0·01 included S-values from zero to 0·0149 while the value group of nominal centre value 0·14 included S-values from 0·135 upwards.

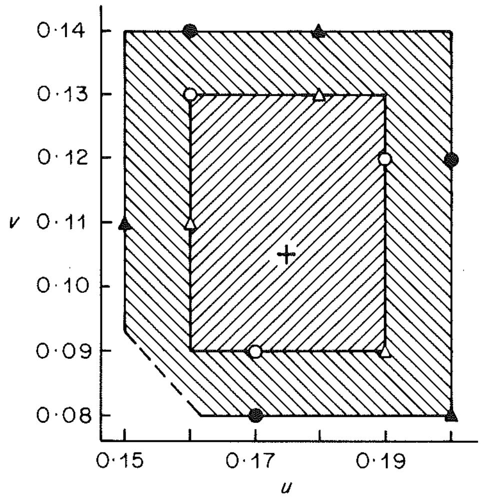
Equation 6 gives only the magnitude of the '5% probability' reliability vector, but not its direction, and it may therefore be assumed that the true shift of reproduced chromaticity lies within the circle of radius $C_{5\%}$ and having its centre at the co-ordinates ($E_{u\mathrm{T}}$, $E_{v\mathrm{T}}$) as derived from Equations 1 and 2. The value of $S_{5\%}$ used in Equation 6 is determined by the phosphor group category; thus the value 0·08 is taken if none of the phosphor chromaticities lie outside the inner areas shown in Fig. 3, or as 0·13 if any phosphor chromaticities lie outside these areas.

$$C_{5\%} = S_{5\%} \left[(E_{u\mathrm{R}}{}^2 + E_{v\mathrm{R}}{}^2)^{½} + (E_{u\mathrm{G}}{}^2 + E_{v\mathrm{G}}{}^2)^{½} + (E_{u\mathrm{B}}{}^2 + E_{v\mathrm{B}}{}^2)^{½} \right] \qquad (6)$$



(a) Red Phosphor

(b) Green Phosphor



(c) Blue Phosphor

Fig. 3 - Categories of phosphor chromaticity groups

▧ *Boundary category* {● *Group 1*, ▲ *Group 2*}

▨ *Inner category* {○ *Group 3*, △ *Group 4*}

– – – *Spectrum locus*

+ *System I chromaticity*

2.2.3 A worked example

Consider the case where the phosphor chromaticities are as follows:

Red $u = 0{\cdot}420; \quad v = 0{\cdot}337$
Green $u = 0{\cdot}134; \quad v = 0{\cdot}367$
Blue $u = 0{\cdot}187; \quad v = 0{\cdot}130$

The error in reproduction of Test Colour CIE 2 is required. The chromaticity error diagrams (see Appendix) are reproduced in Figs. 5a–5c, with the error vectors (R, G, B) resulting from the above phosphor chromaticities superimposed. It can be seen that the chromaticity error co-ordinates are:

Red $E_{u\mathrm{R}} = -0{\cdot}0008; \; E_{v\mathrm{R}} = -0{\cdot}0026$
Green $E_{u\mathrm{G}} = -0{\cdot}0022; \; E_{v\mathrm{G}} = -0{\cdot}0022$
Blue $E_{u\mathrm{B}} = -0{\cdot}0022; \; E_{v\mathrm{B}} = -0{\cdot}0003$

Thus from Equations 1 and 2 the total chromaticity error co-ordinates are:

$$E_{u\mathrm{T}} = -0{\cdot}0052 \qquad E_{v\mathrm{T}} = -0{\cdot}0051$$

The degree of accuracy involved in the use of the graphical method is assessed by first noting that as the phosphor chromaticities all fall within (or lie on the boundary of) the inner areas shown on Fig. 3, the calue of $S_{5\%}$ to be used in Equation 6 is 0·08. From Equation 6 the value of $C_{5\%}$ is thus 0·00064.

The individual error vectors (R, G, B), the total error vector (T) and the 'degree of accuracy' circle are shown in Fig. 6.

3. Test colours BBC 9 (M) and BBC 14 (M)

Test colour BBC 9 is a desaturated blue and test colour BBC 14 is a desaturated red. It can be seen from Table 3, which shows the chromaticity co-ordinates and

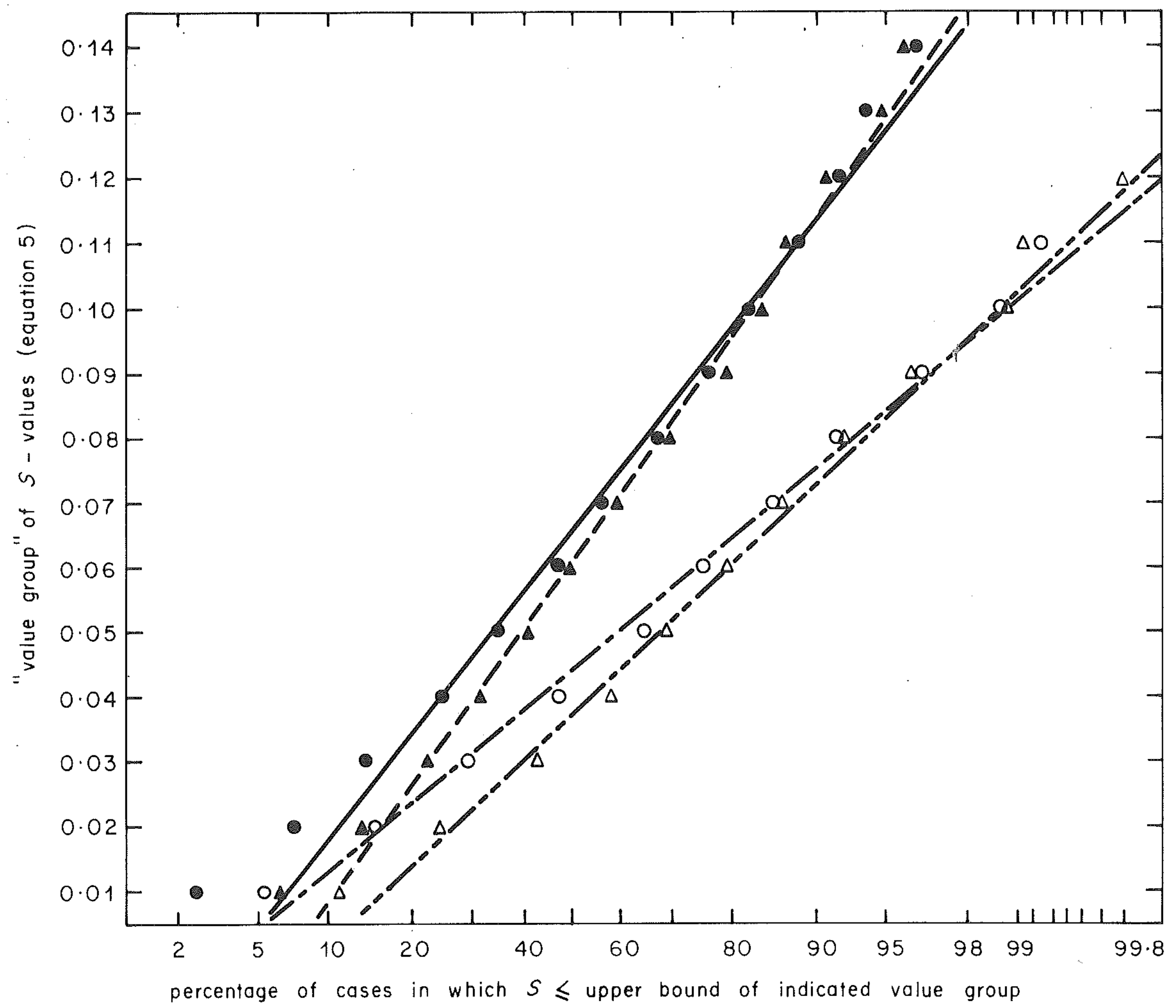


Fig. 4 - Cumulative probability plots of S-values (see text)

Phosphor chromaticity groups: ●—● 1 ▲—▲ 2 ○–·–○ 3 △– –△ 4

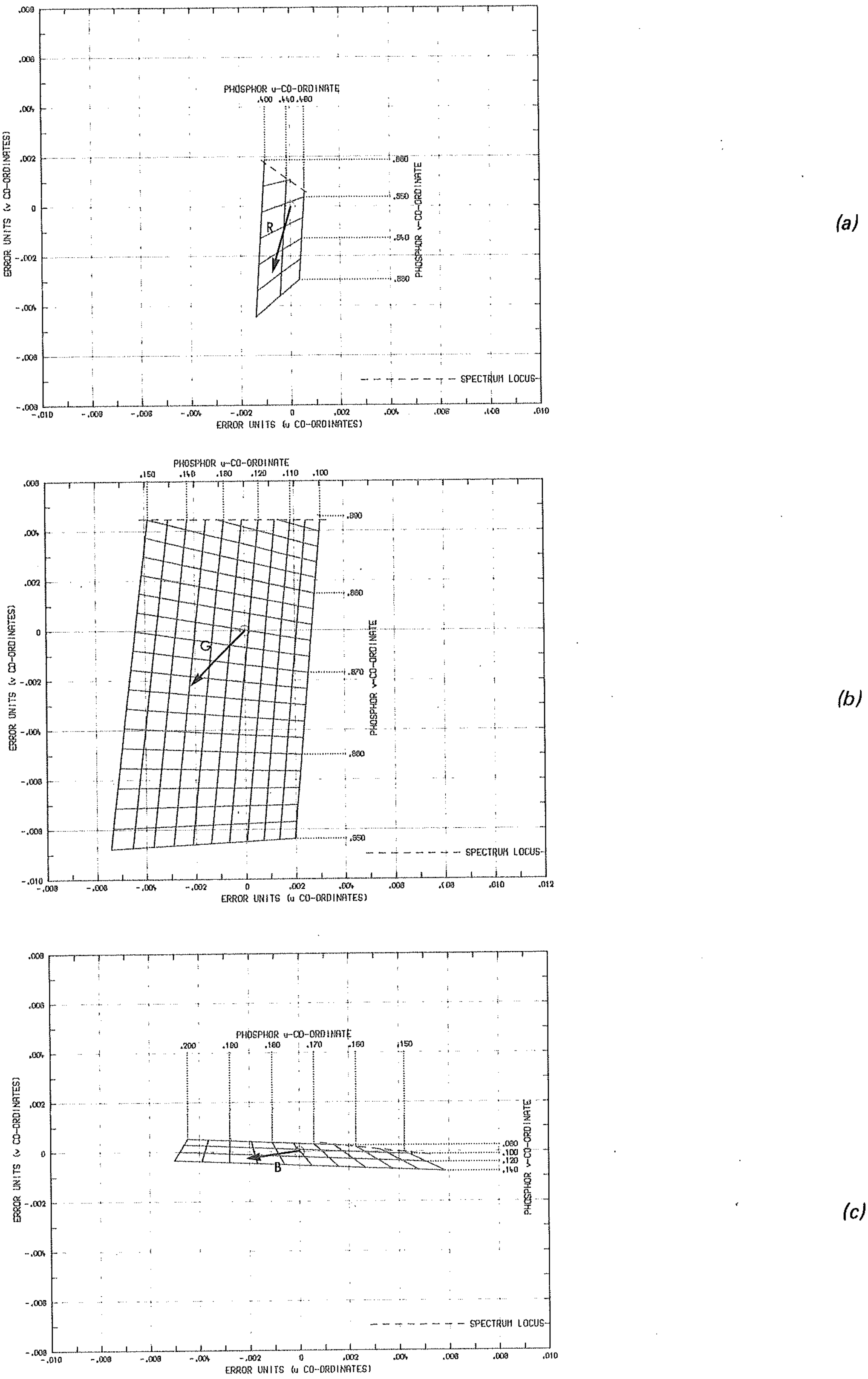


Fig. 5 - Example of use of chromaticity error diagrams

R, G, B - *Error vectors for red, green and blue phosphors*

(a)	*Diagram for red phosphor*	*Phosphor co-ordinates:*	$u = 0{\cdot}420$	$v = 0{\cdot}337$	*Error co-ordinates:*	$E_{uR} = -0{\cdot}0008$ $E_{vR} = -0{\cdot}0026$
(b)	*Diagram for green phosphor*	*Phosphor co-ordinates:*	$u = 0{\cdot}134$	$v = 0{\cdot}367$	*Error co-ordinates:*	$E_{uG} = -0{\cdot}0022$ $E_{vG} = -0{\cdot}0022$
(c)	*Diagram for blue phosphor*	*Phosphor co-ordinates:*	$u = 0{\cdot}187$	$v = 0{\cdot}130$	*Error co-ordinates:*	$E_{uB} = -0{\cdot}0022$ $E_{vB} = -0{\cdot}0003$

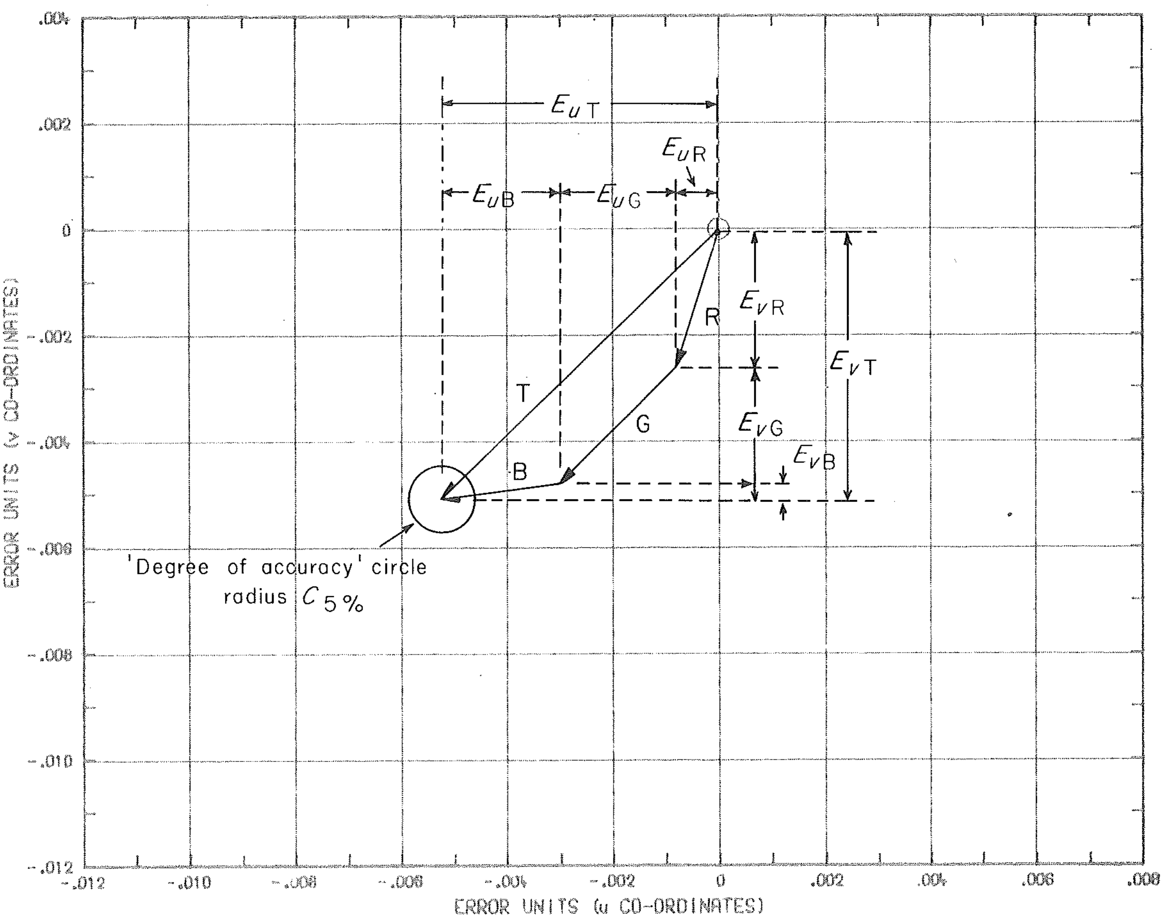


Fig. 6 - Summation of individual phosphor errors

R, G, B - *Error vectors for red, green and blue phosphors*
T - *Total error vector*

Table 3

Test Colour	Chromaticity Co-ordinates		Colour Separation Signals (% relative to white)		
	u	v	Red	Green	Blue
9	0·1924	0·2646	27·15	27·30	65·76
14	0·3213	0·3307	48·09	8·33	8·11

Two desaturated test colours

colour separation signal magnitudes of these two test colours, that in both cases two of the colour-separation signals are very nearly equal and are smaller than the third signal. In colorimetric terms, exact equality of the two smaller colour-separation signals implies that the test colour has the same dominant wavelength[2c] as the primary corresponding to the larger colour-separation signal, and therefore that, on the (u,v) diagram, the chromaticity of the test colour lies on the straight line (line of constant dominant wavelength) which passes through the chromaticity of the phosphor and the white point.* For test colours having such chromaticities, the phosphor chromaticity grids (see Section 2.1) for the two phosphors supplied with equal colour-separation signals take the form of straight lines which are in both cases part of the above-mentioned line of constant dominant wavelength.** This implies that any variation in the chromaticity of either of these two phosphors, whether in the u-direction or the v-direction, gives rise only to a change in saturation of the test colour, without affecting its dominant wavelength (although equal shifts of phosphor chromaticity in the u- and v-directions do not necessarily cause equal changes of saturation). In the present context, the chromaticity error diagram for either of these two phosphors would be ambiguous, since the 'lines of constant u' and 'lines of constant v' in the phosphor chromaticity grid would be superimposed and thus indistinguishable from each other.

The chromaticities of test colours BBC 9 and BBC 14, relative to the relevant lines of constant dominant wavelength, are shown in Fig. 7. For clarity, enlargements of the chromaticity diagram in the regions occupied by these test colours are shown in this figure, since the chromaticity differences under discussion are too small to be seen clearly on a diagram covering the whole gamut of colours reproducible on a colour display. Although in each case the test-colour chromaticity does not lie precisely on the relevant line of constant dominant wavelength it is sufficiently near to this line to give rise to a 'straight-line' phosphor chromaticity grid as described above. For the purpose of obtaining unambiguous chromaticity error diagrams, the colour separation signal values for each of the test colours have been modified so that the test-colour chromaticities lie further from these lines of constant dominant wavelength (test colours BBC 9 (M) and BBC 14 (M) in Fig. 7). Only the minimum shift of test-colour chromaticity required to 'open up' the phosphor chromaticity grids, so that the phosphor u- and v-co-ordinate lines can be readily distinguished, has been chosen. This procedure clearly introduces a further loss of accuracy into the determination of the chromaticity errors of the original test colours, but it is thought that the method adopted represents the best compromise between loss of accuracy and ease of interpreting the diagrams. The colour-separation signals of the two modified test colours have been adjusted so that the luminance of each of the two modified colours is the same as that of the corresponding original test colour.

4. Conclusions

As far as the effect of the chromaticity error (with respect to the System I value) of any one phosphor in a television display is concerned, the precision of the graphical method in evaluating the resulting error in test-colour reproduction is limited only by the accuracy with which the appropriate error diagram may be read. Some loss of precision does however occur when the chromaticity of more than one display phosphor differs from the System I value, since the error diagram for each phosphor is derived on the assumption that the other two phosphors have the correct System I chromaticities. Over the range of phosphor chromaticities covered by the error diagrams, the test-colour chromaticity co-ordinate values obtained by the use of the error diagrams are likely, on a statistical basis, to be accurate to within a tolerance given, at worst, by 13% of the scalar sum of the errors in test-colour reproduction found for the individual phosphors. Greater accuracy is obtainable over a more restricted range of phosphor chromaticities, which nevertheless includes most cases likely to be encountered in practice (see Fig. 3), with the result that the numerical value of the tolerance (as described above) decreases to 8%.

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* If the two equal colour-separation signals are greater in magnitude than the third signal (i.e. the test colour is a desaturated complementary colour) the test-colour chromaticity lies on the extension of the straight line passing through the chromaticity of the phosphor to which the test colour is complementary, and the white point.

** Remembering (see Section 2.1) that the error-unit grid of the chromaticity error diagram is simply an enlargement of the (u,v) diagram in the vicinity of the test colour.

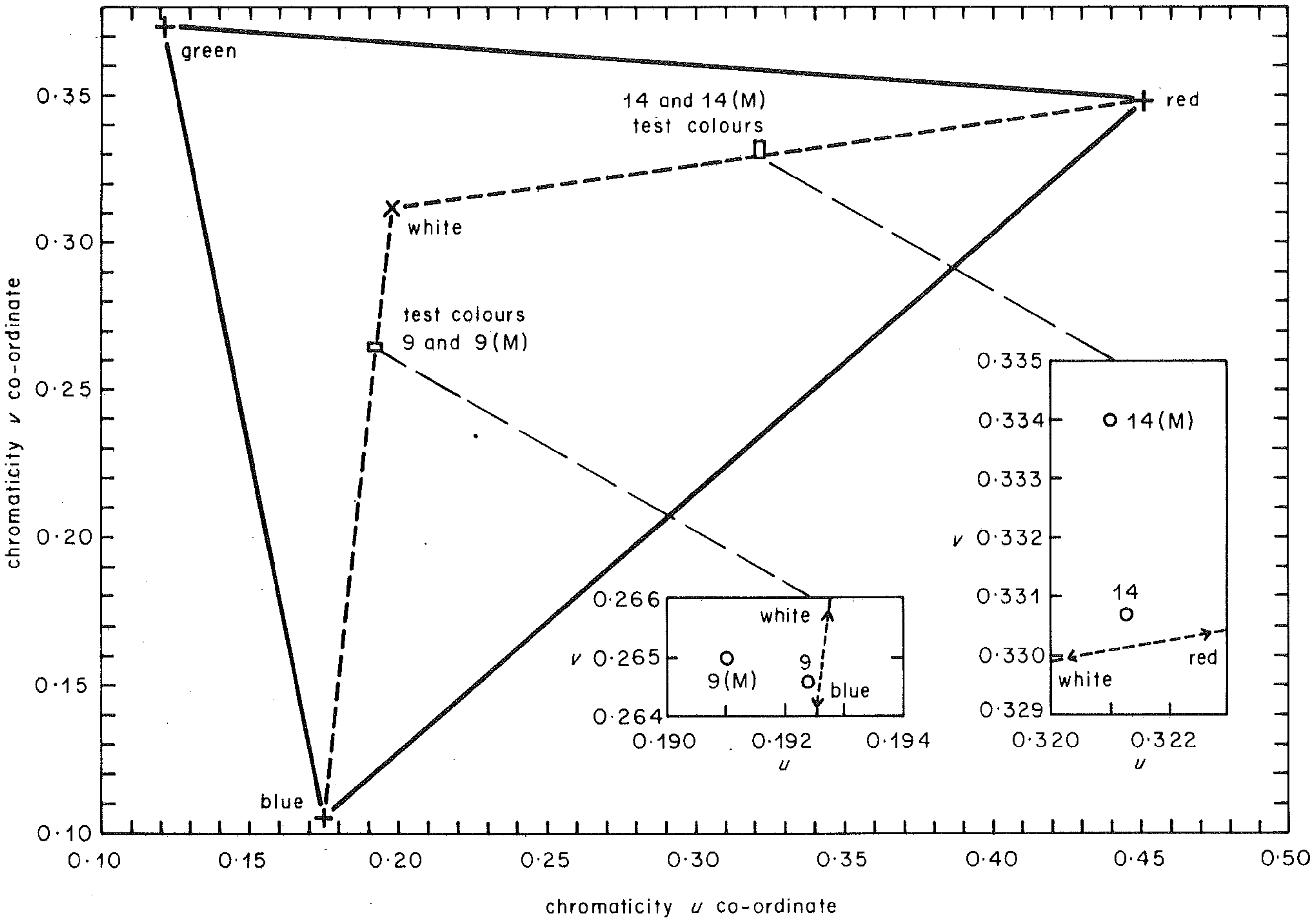

Fig. 7 - Test colours 9, 9(M), 14 and 14 (M)

showing enlargements of the chromaticity diagram in the regions occupied by the test colours

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   2b. Ibid. Section 3.3 (pp. 235–238).
   2c. Ibid. Section 3.5 (p. 321).

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APPENDIX

Chromaticity Error Diagrams

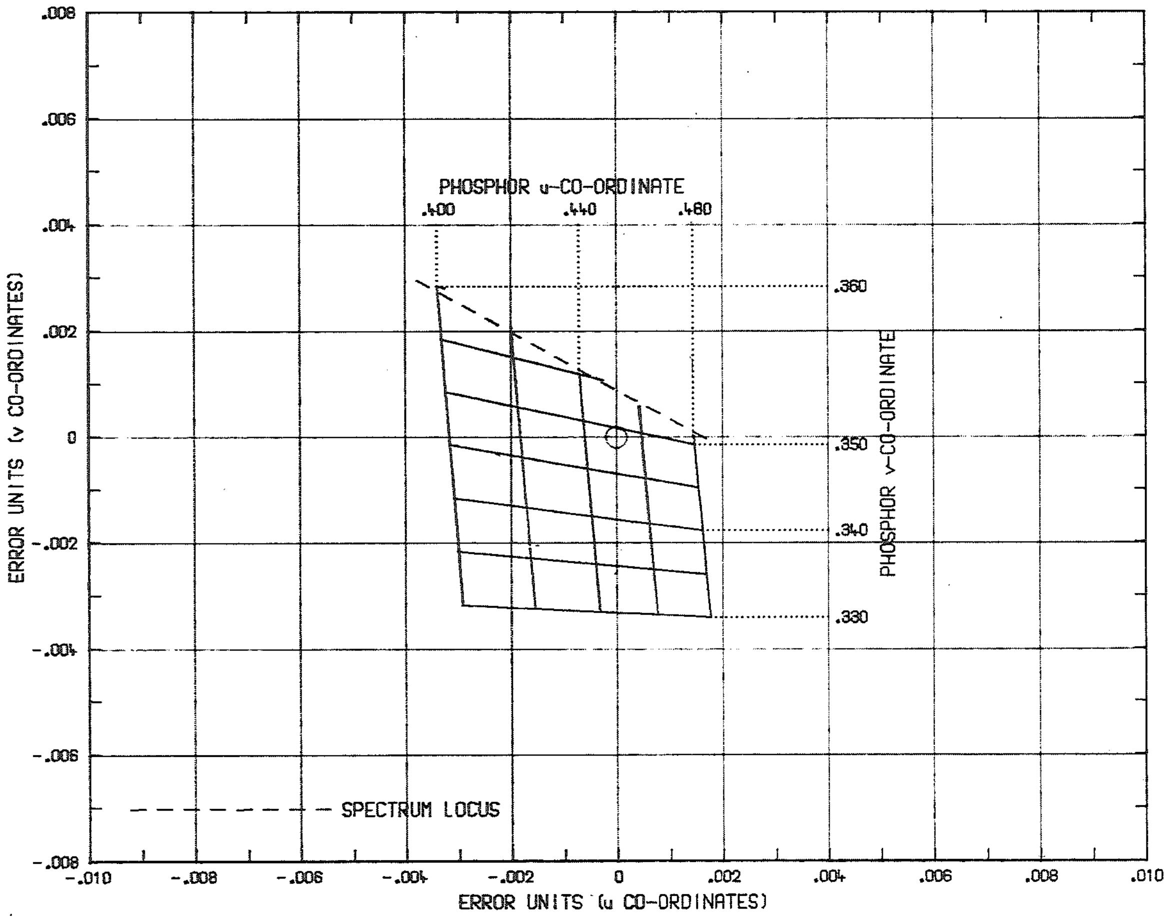
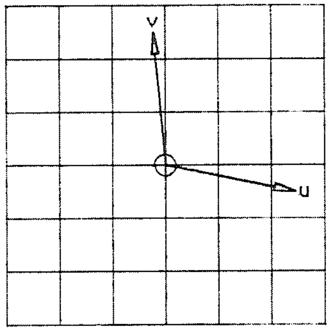
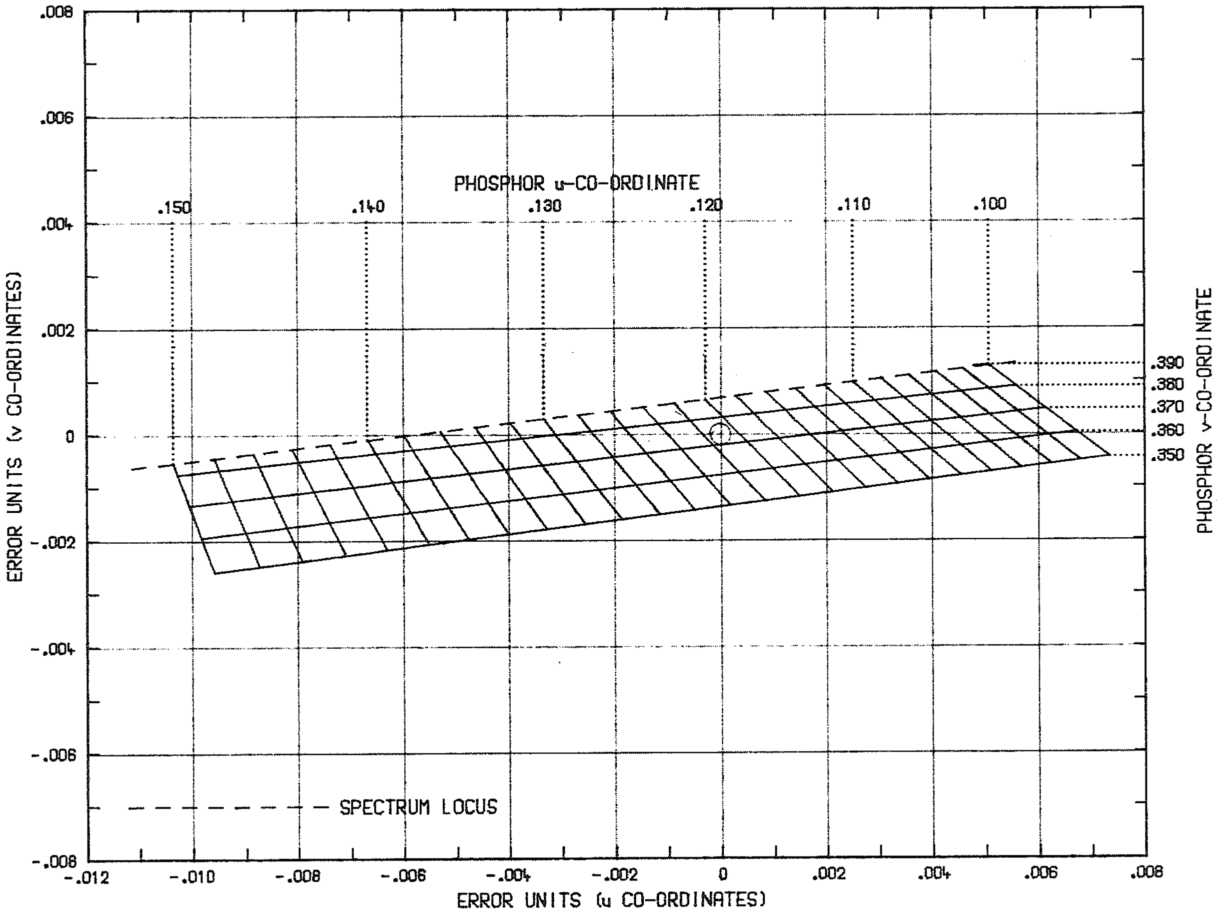


Diagram CIE 1/R
Test Colour CIE 1
Red Phosphor

ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)





ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

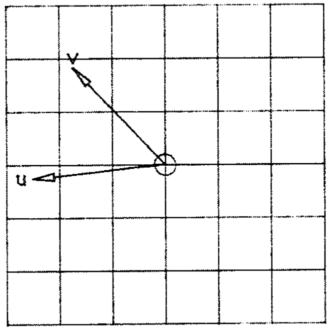
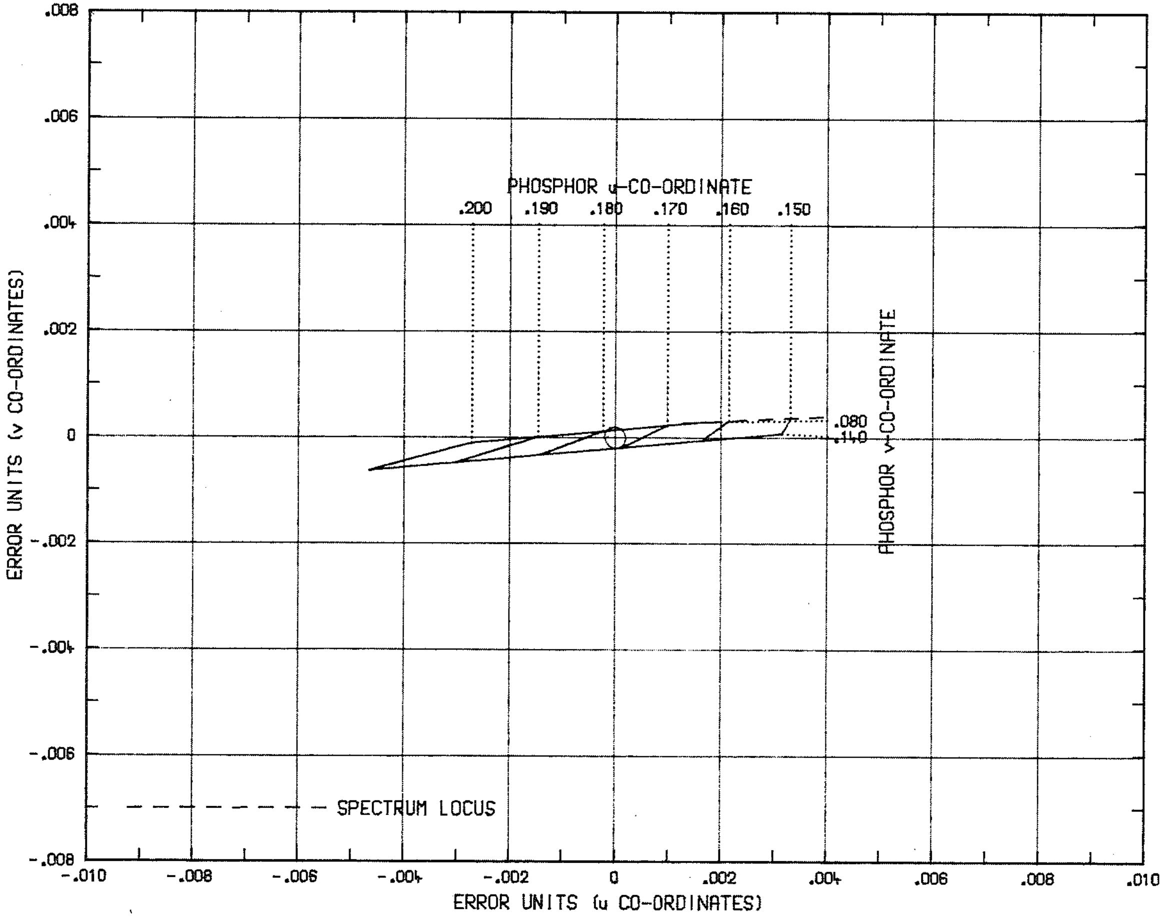


Diagram CIE 1/G
Test Colour CIE 1
Green Phosphor



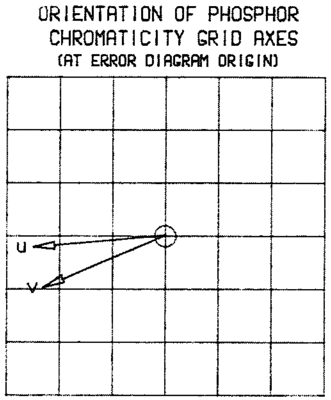
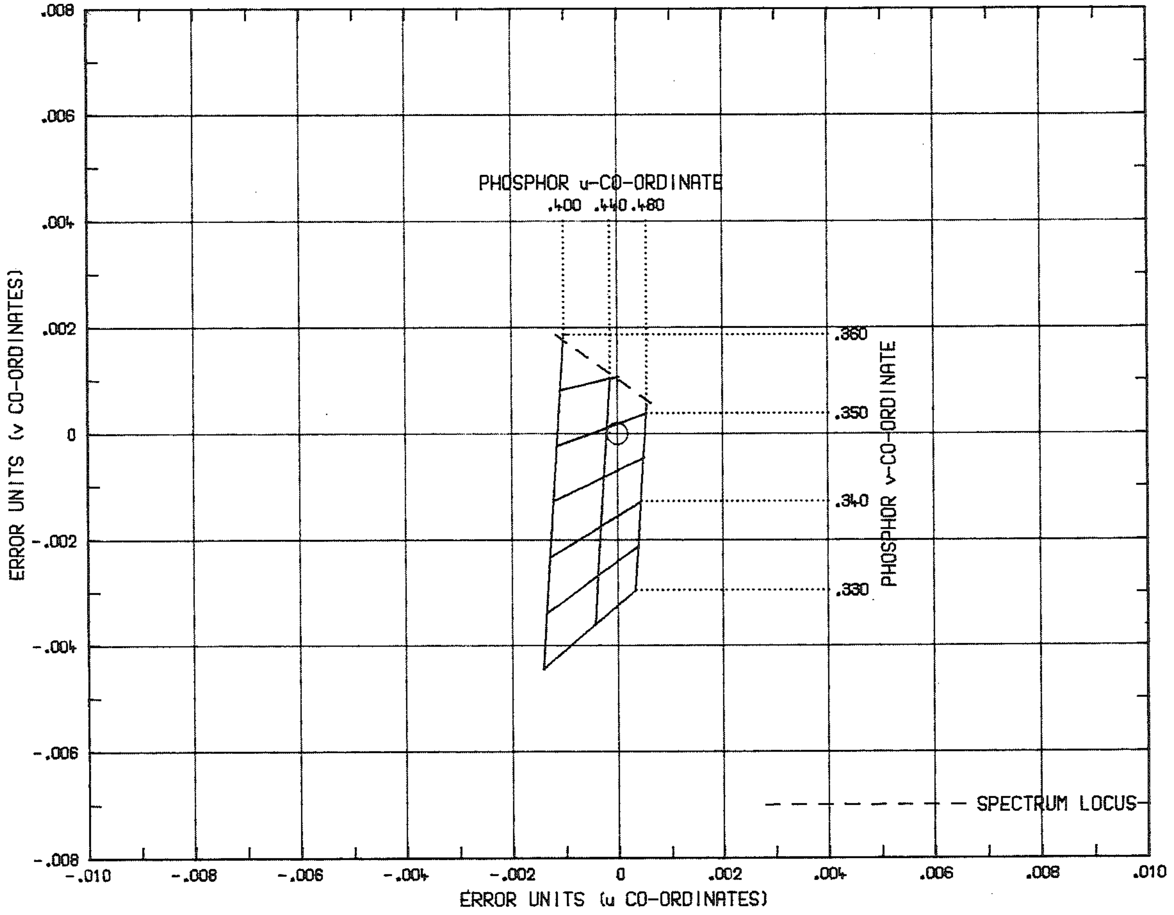


Diagram CIE 1/B
Test Colour CIE 1
Blue Phosphor



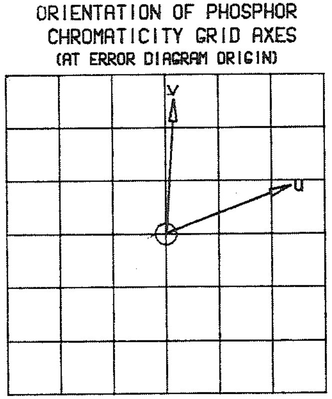


Diagram CIE 2/R
Test Colour CIE 2
Red Phosphor

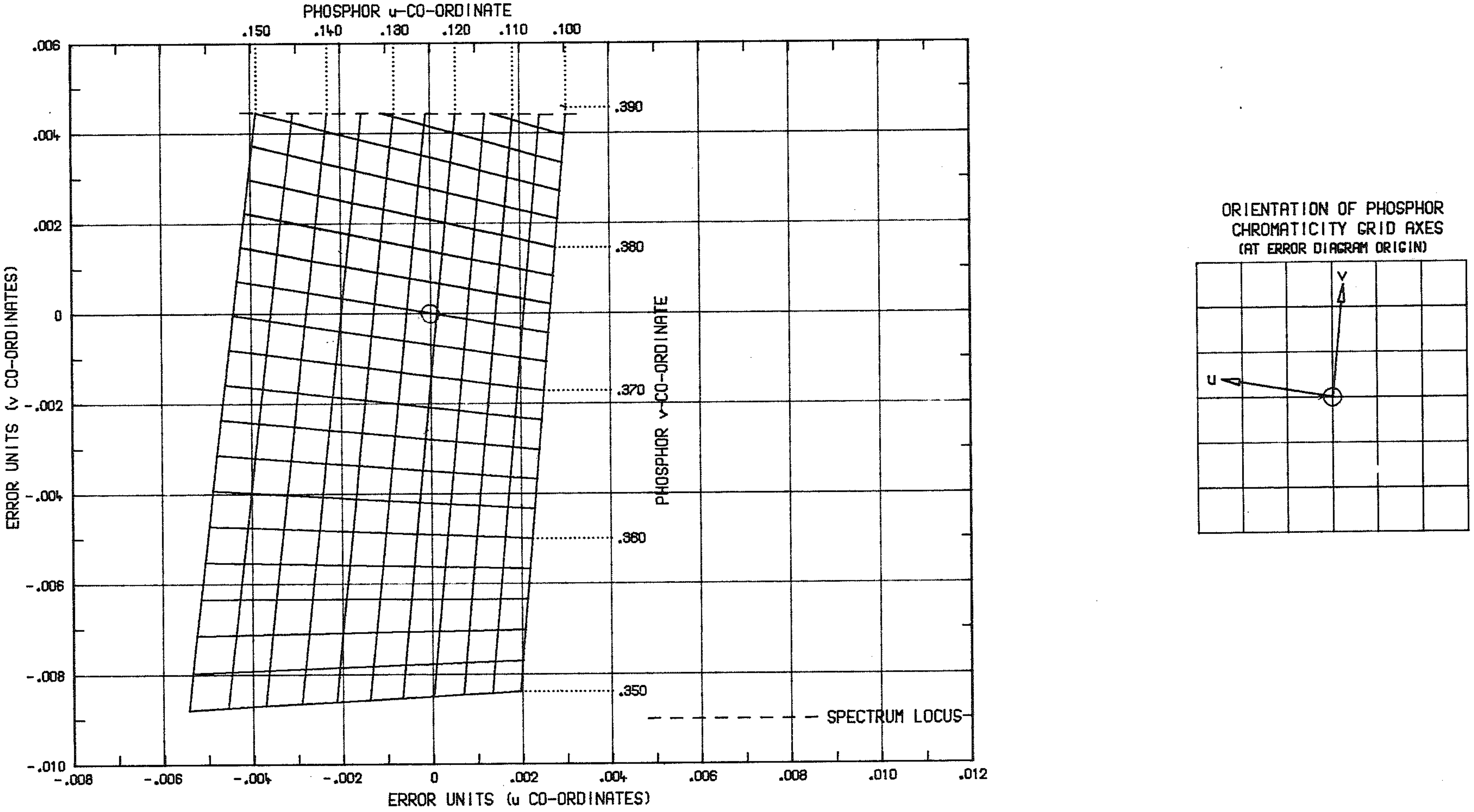


Diagram CIE 2/G
Test Colour CIE 2
Green Phosphor

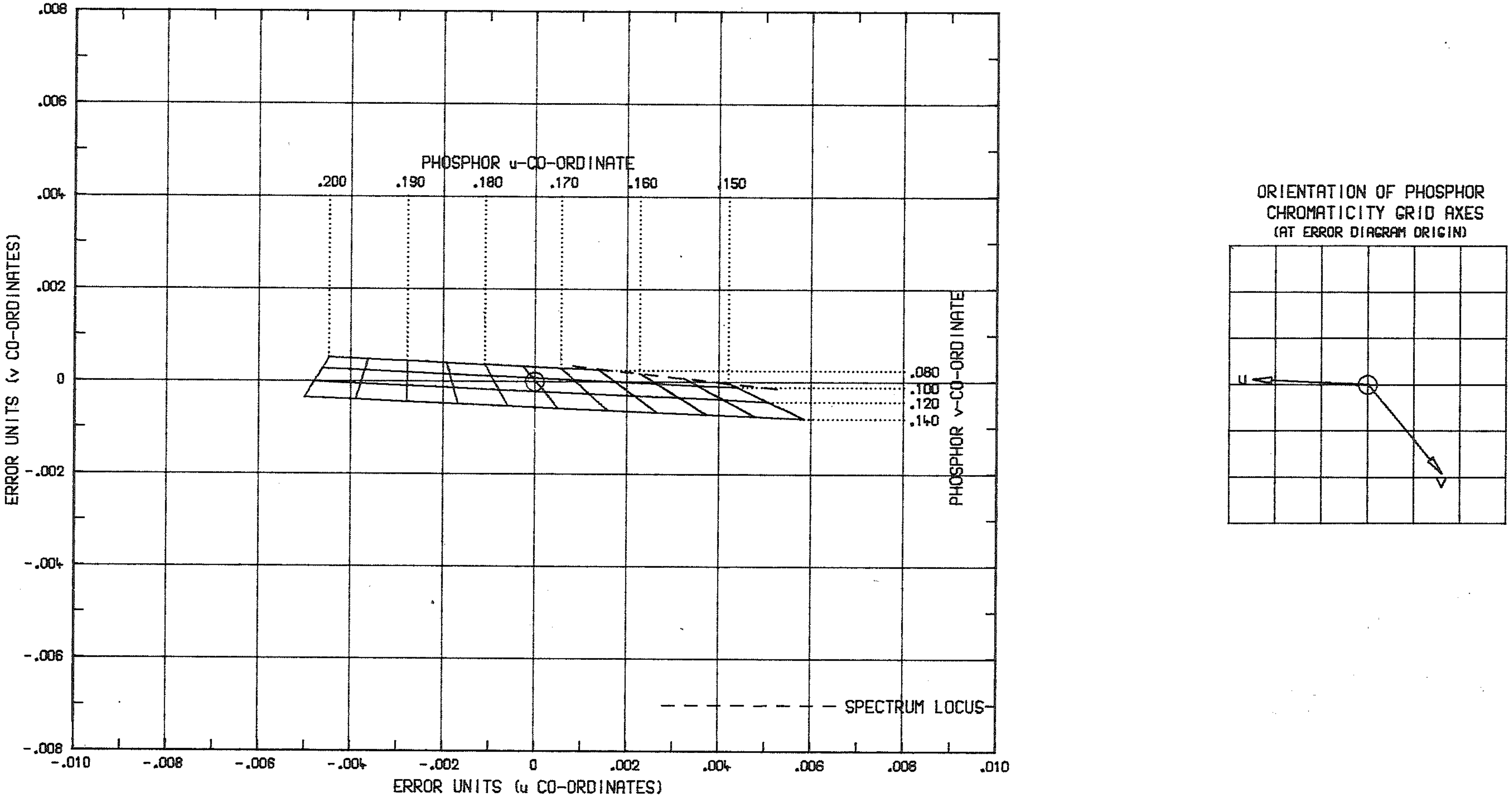
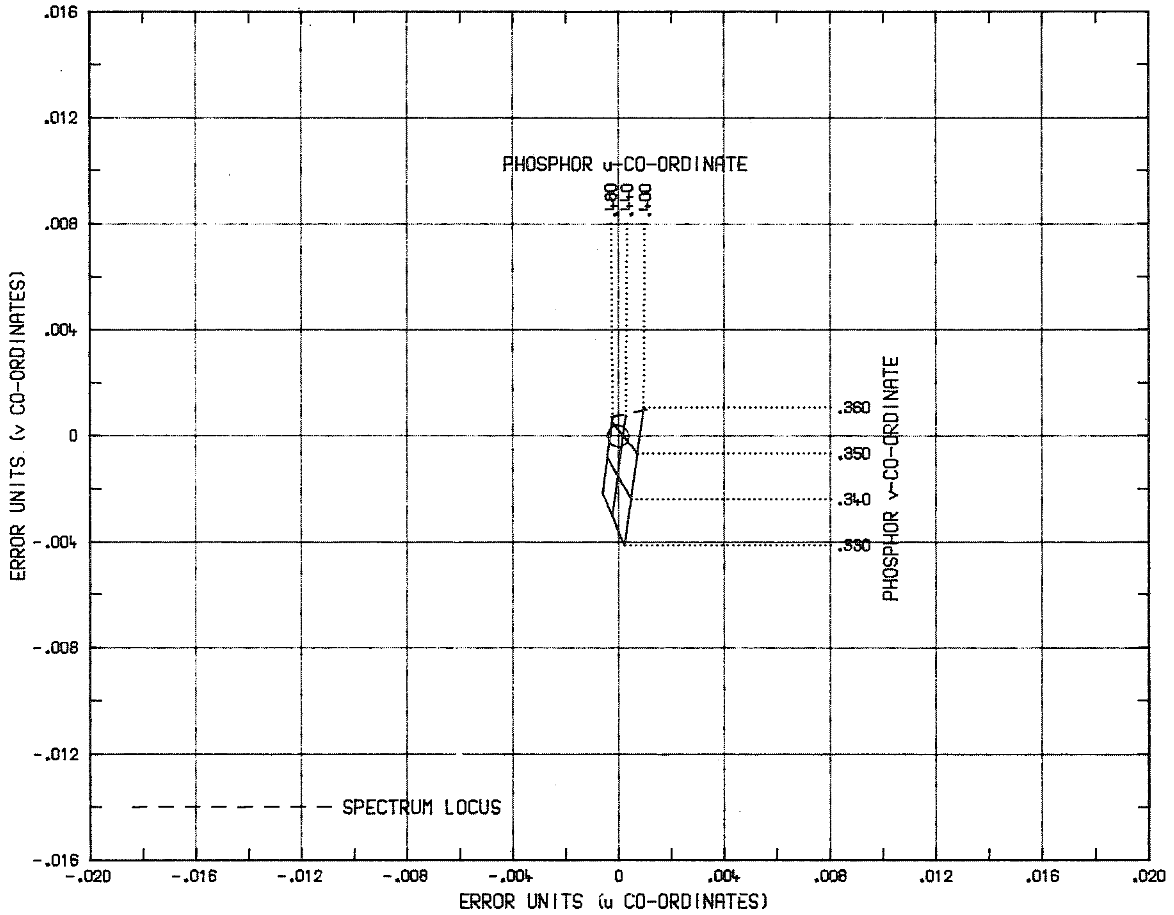


Diagram CIE 2/B
Test Colour CIE 2
Blue Phosphor



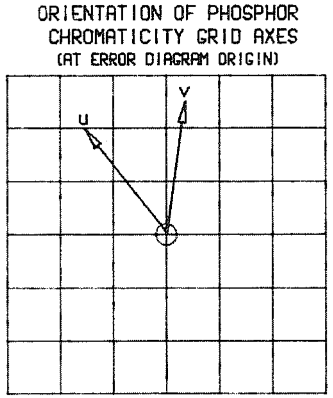
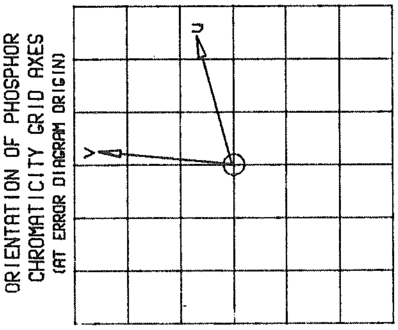


Diagram CIE 3/R
Test Colour CIE 3
Red Phosphor



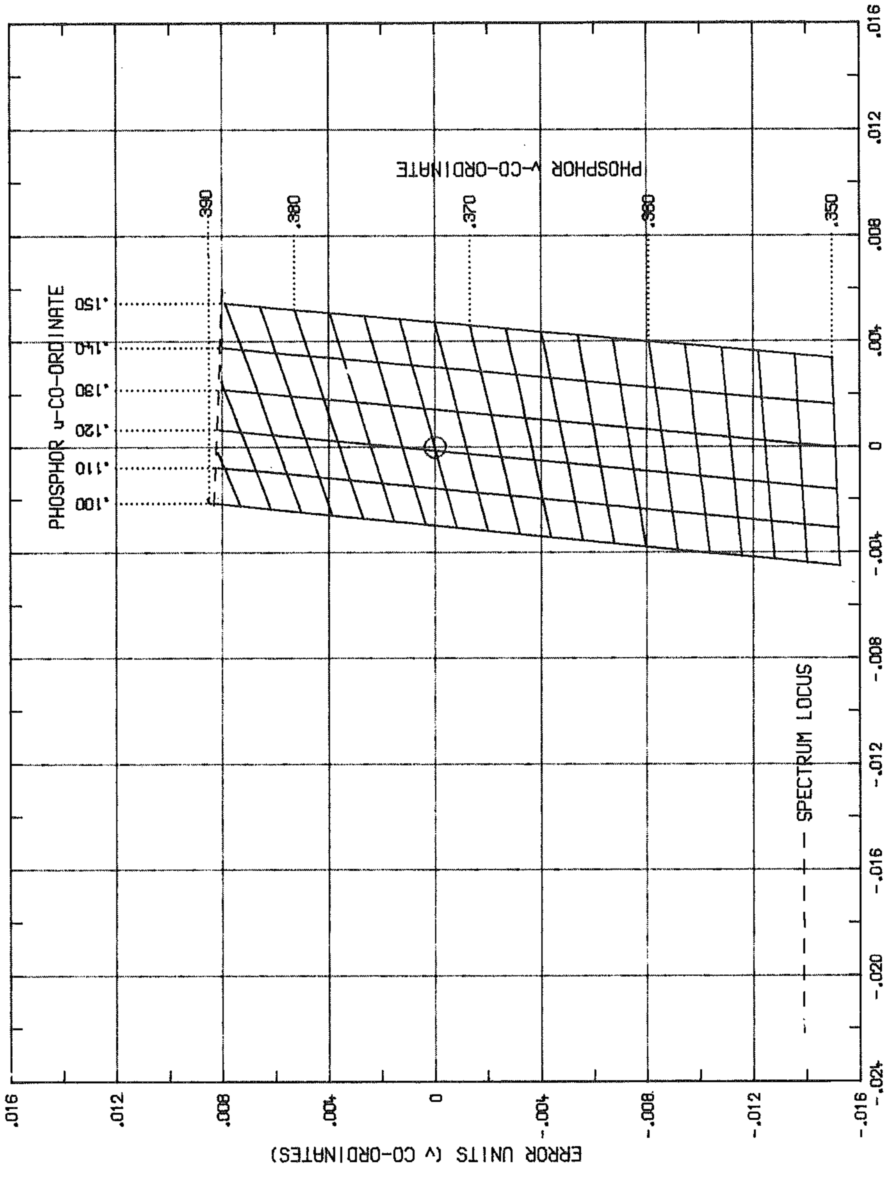
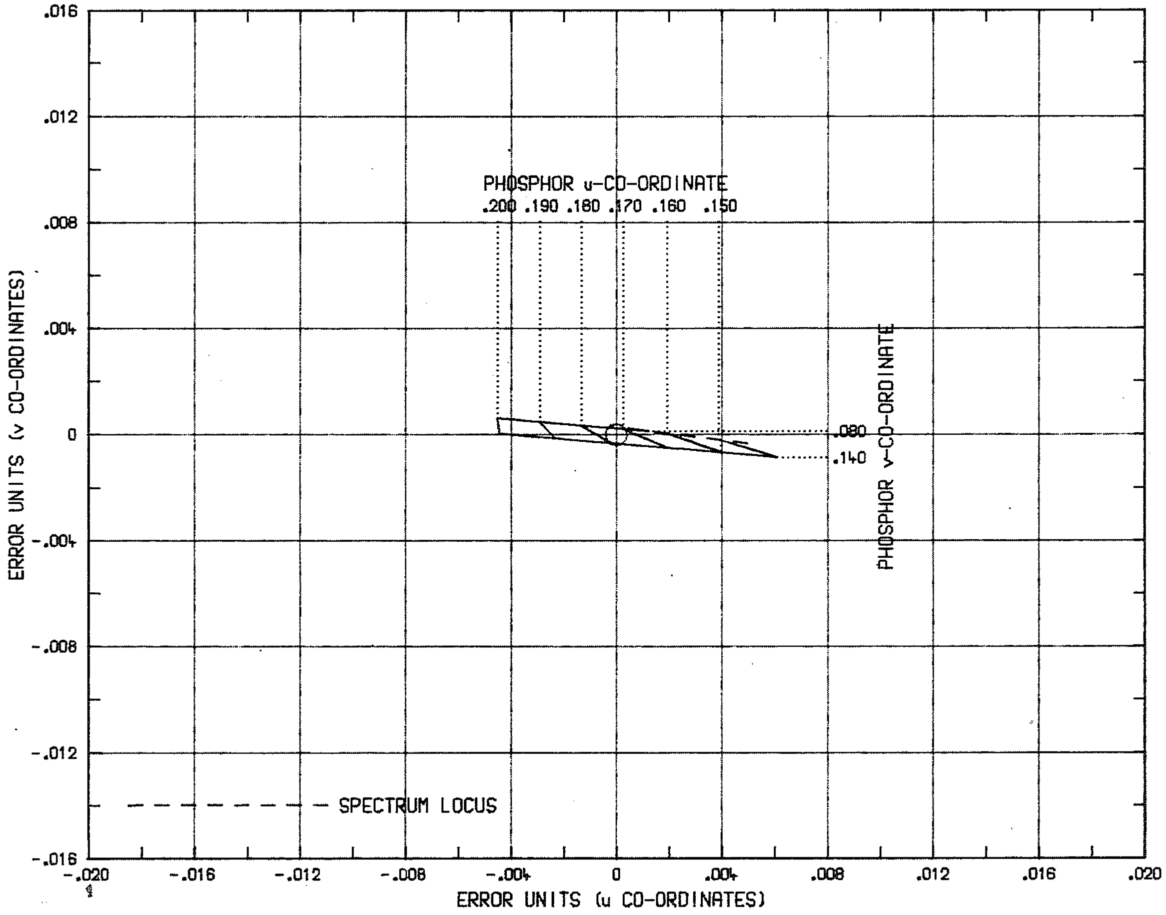


Diagram CIE 3/G
Test Colour CIE 3
Green Phosphor



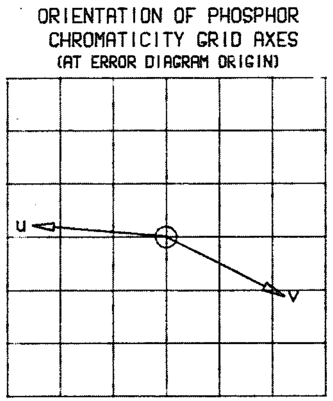


Diagram CIE 3/B
Test Colour CIE 3
Blue Phosphor

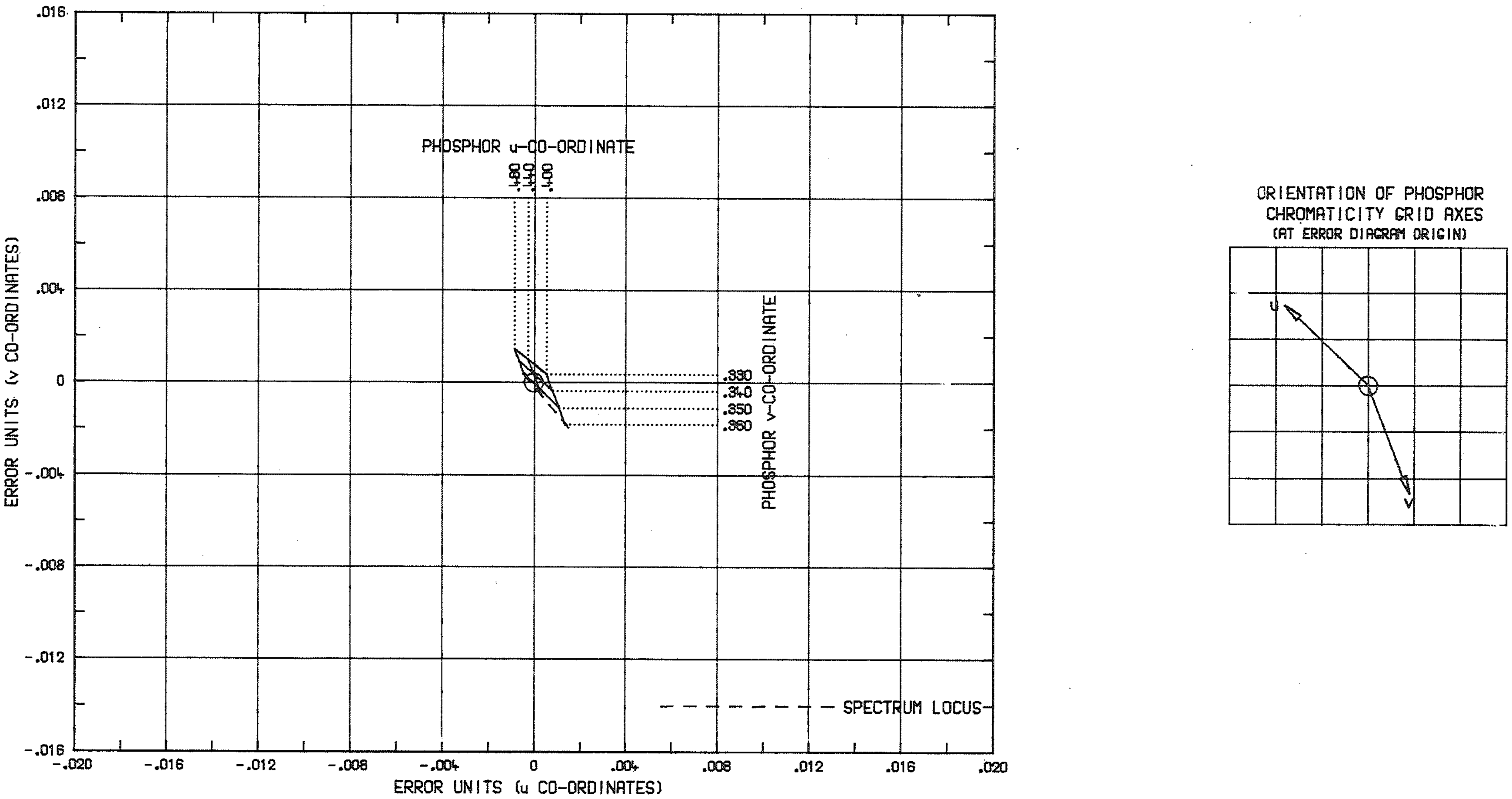
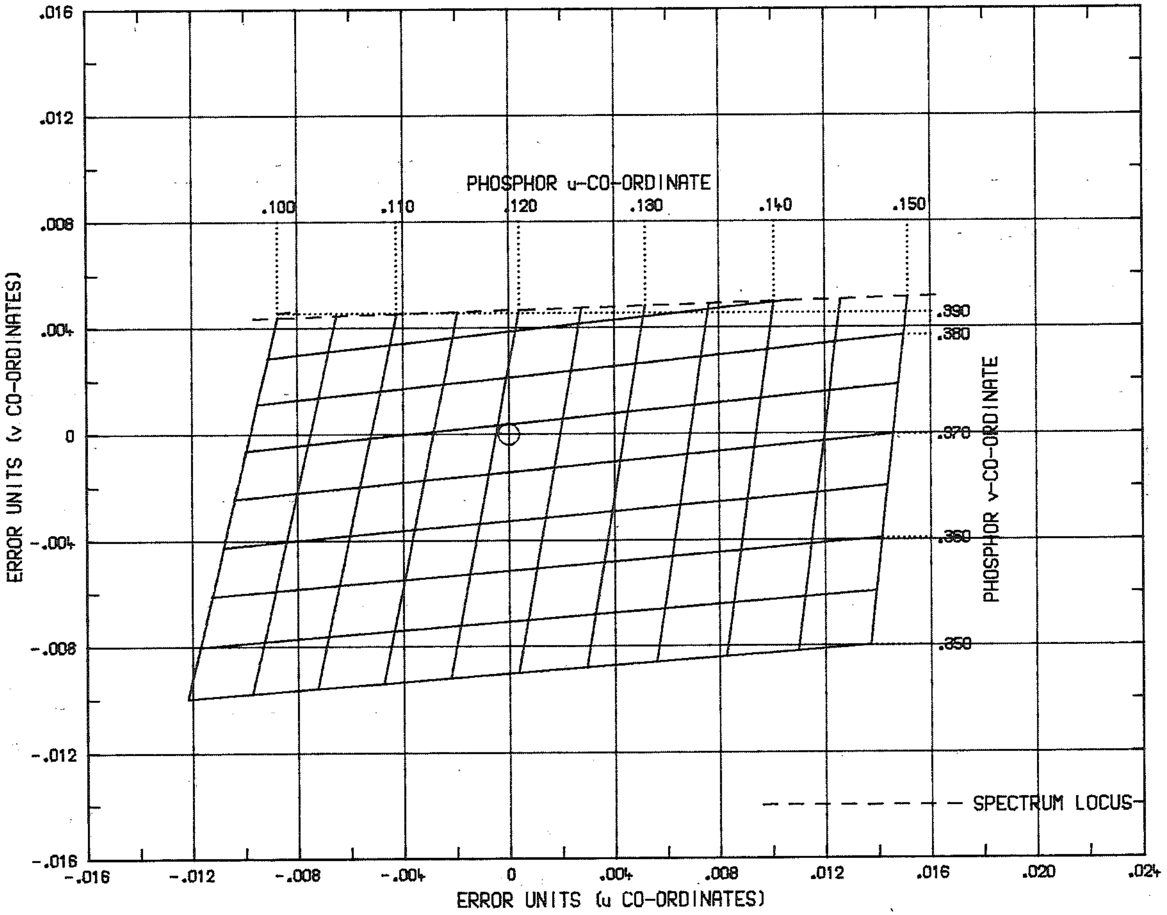


Diagram CIE 4/R
Test Colour CIE 4
Red Phosphor



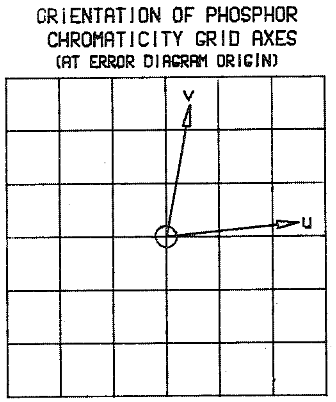


Diagram CIE 4/G
Test Colour CIE 4
Green Phosphor

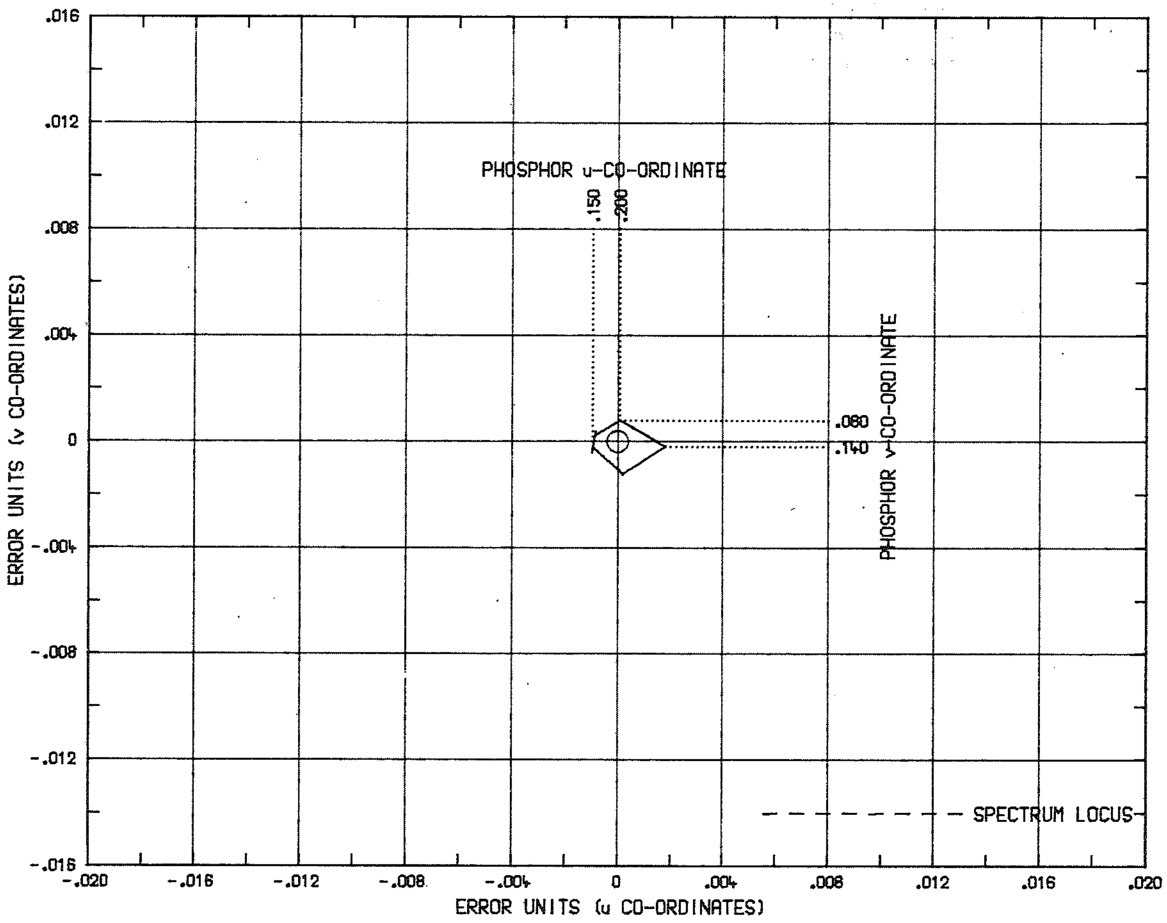
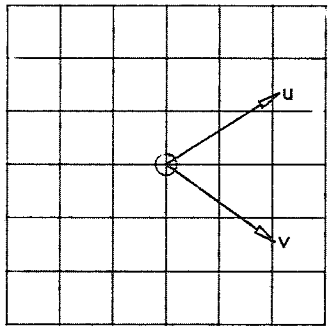
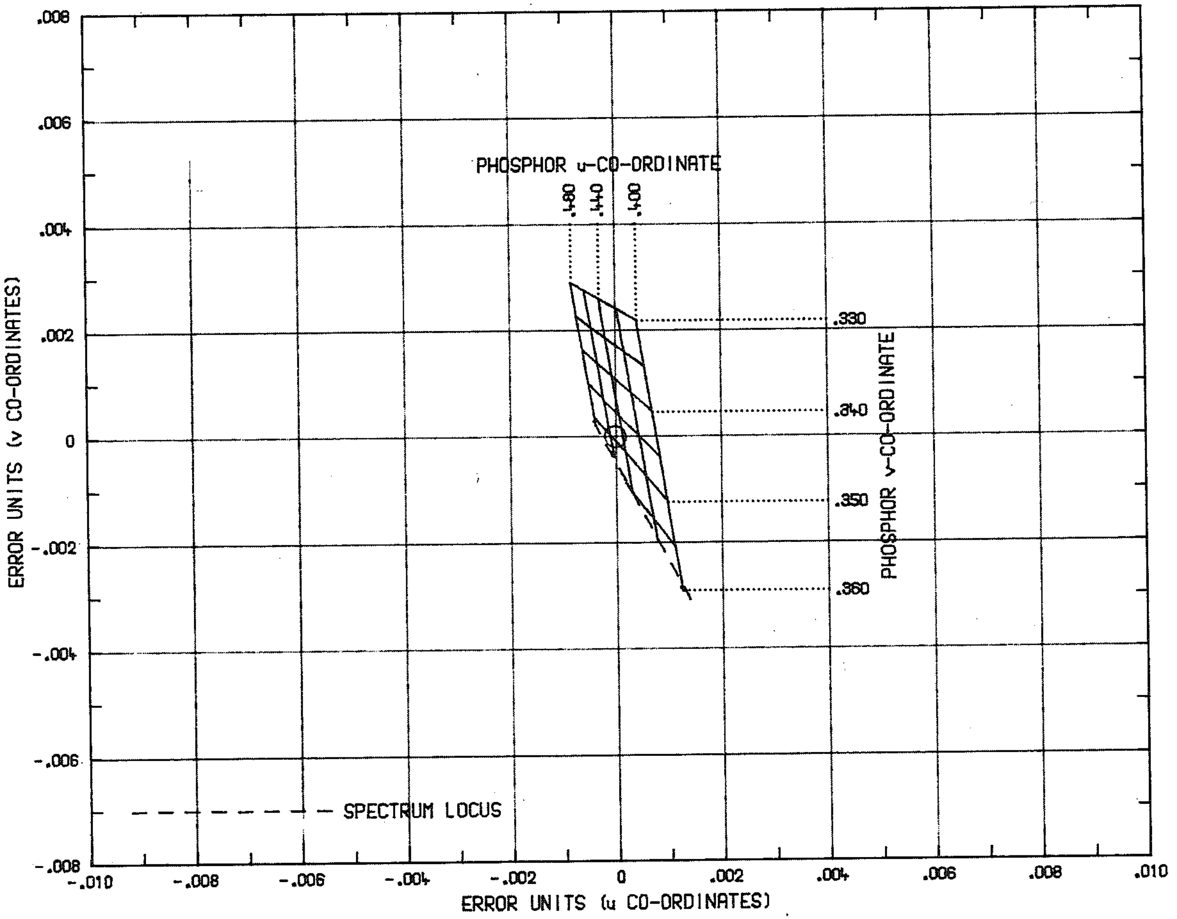


Diagram CIE 4/B
Test Colour CIE 4
Blue Phosphor

ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)





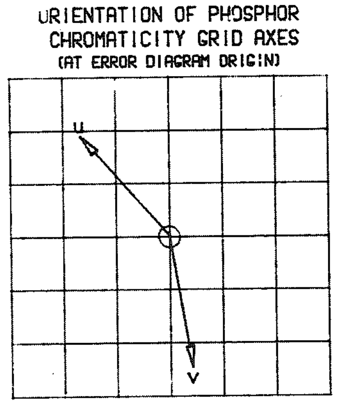


Diagram CIE 5/R
Test Colour CIE 5
Red Phosphor

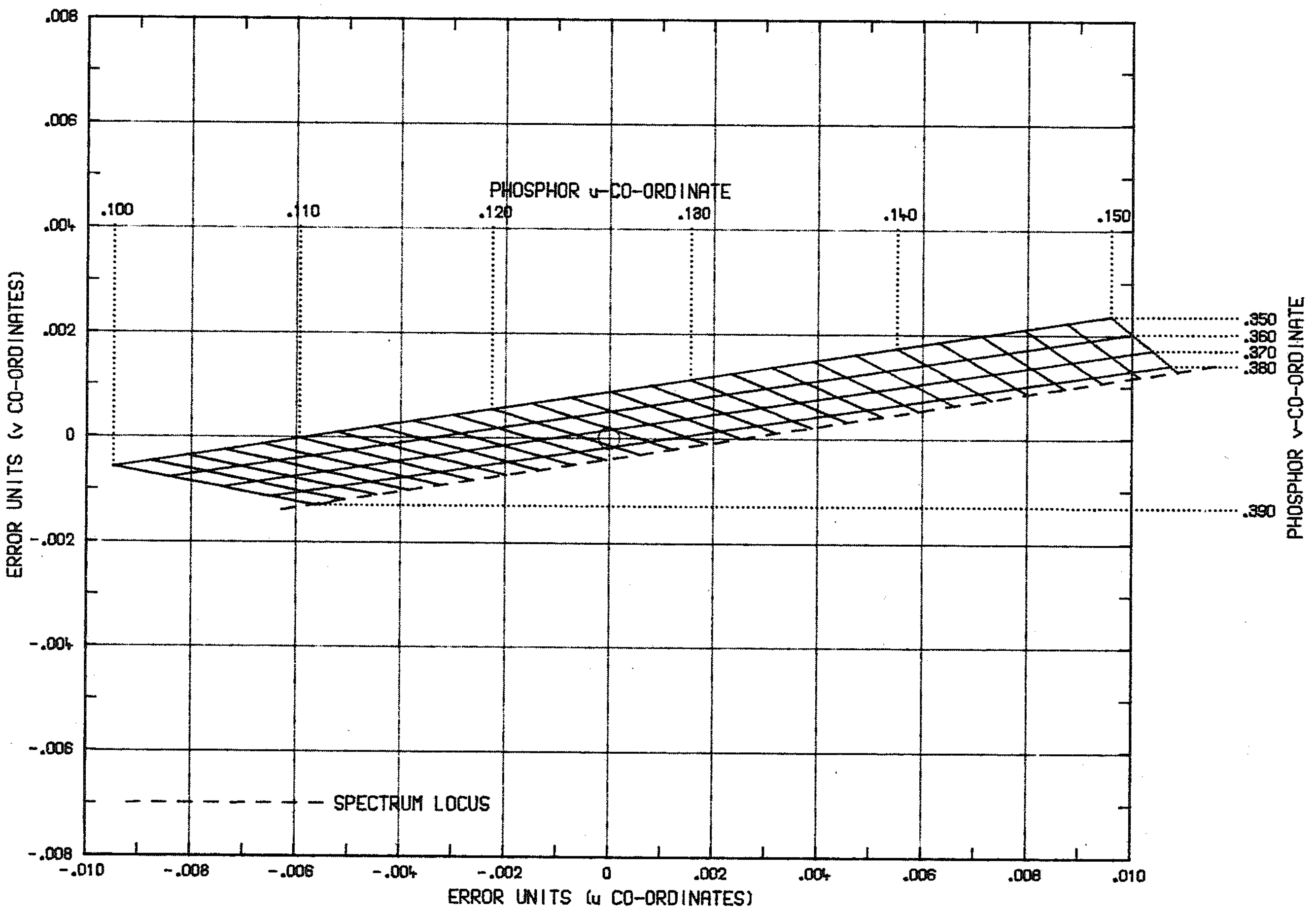
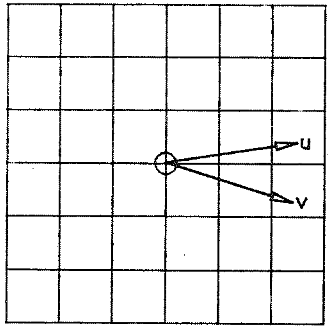
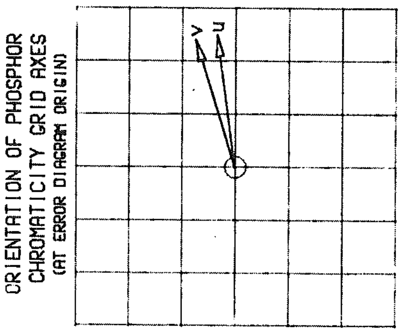


Diagram CIE 5/G
Test Colour CIE 5
Green Phosphor

ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)





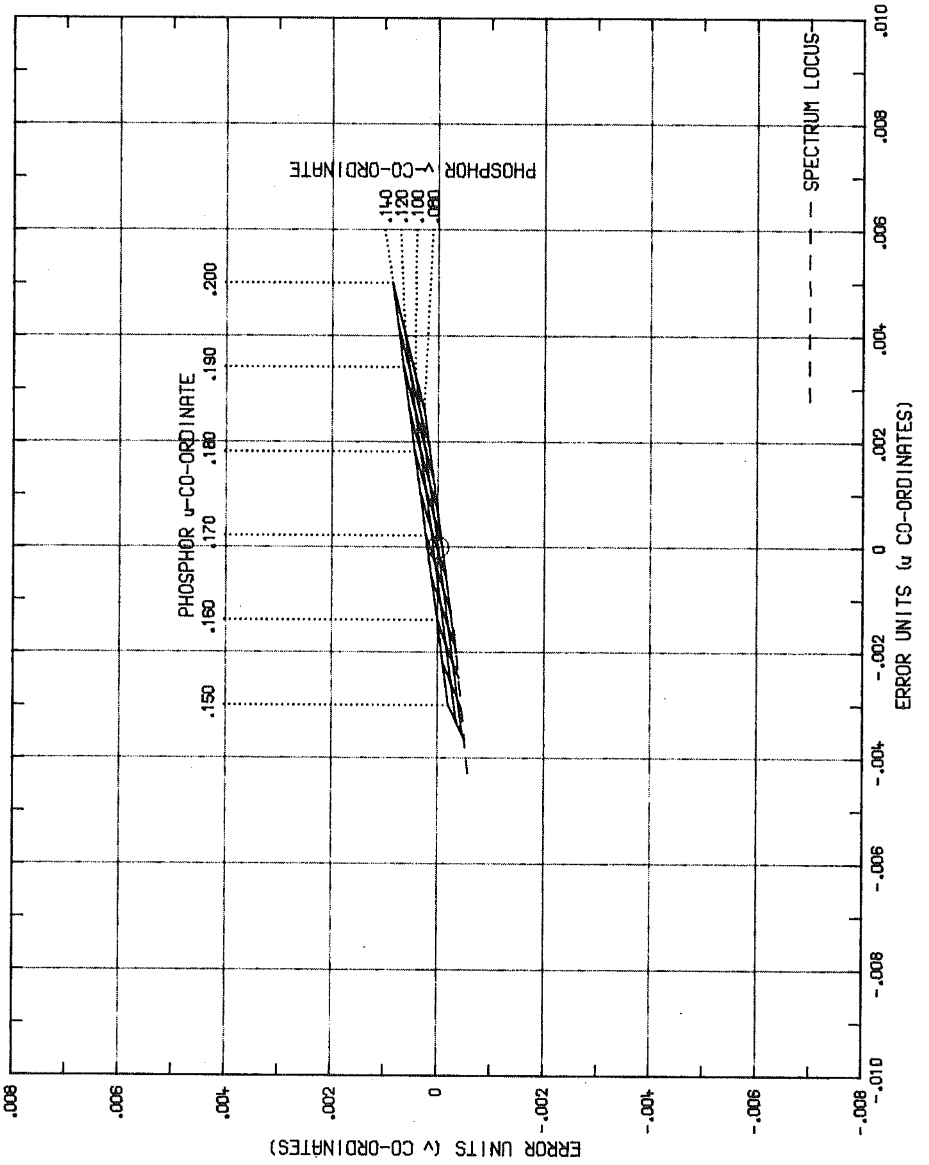
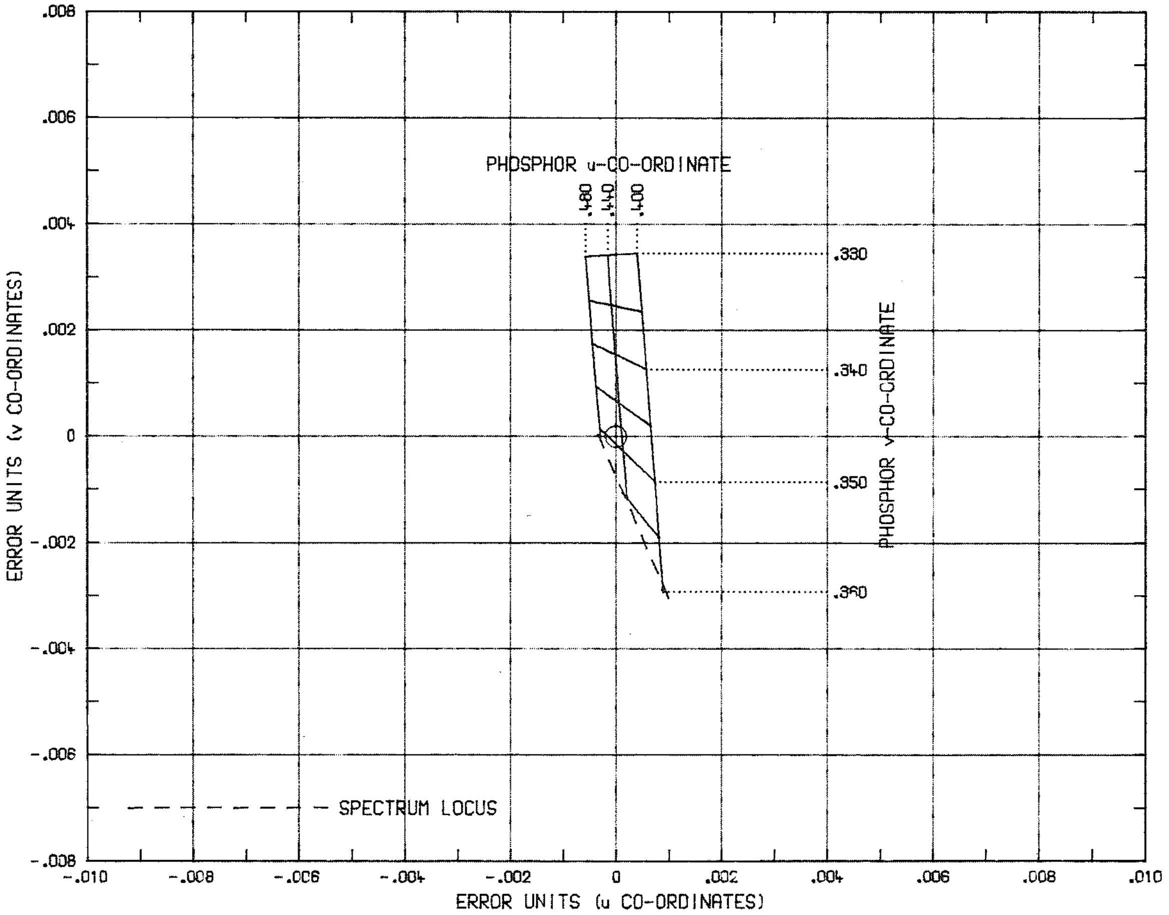


Diagram CIE 5/B

Test Colour CIE 5

Blue Phosphor



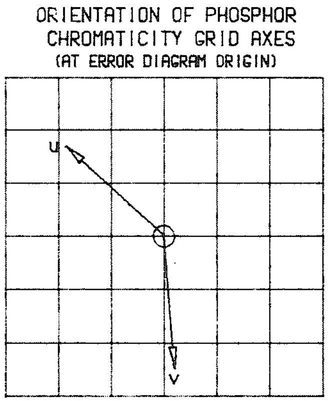
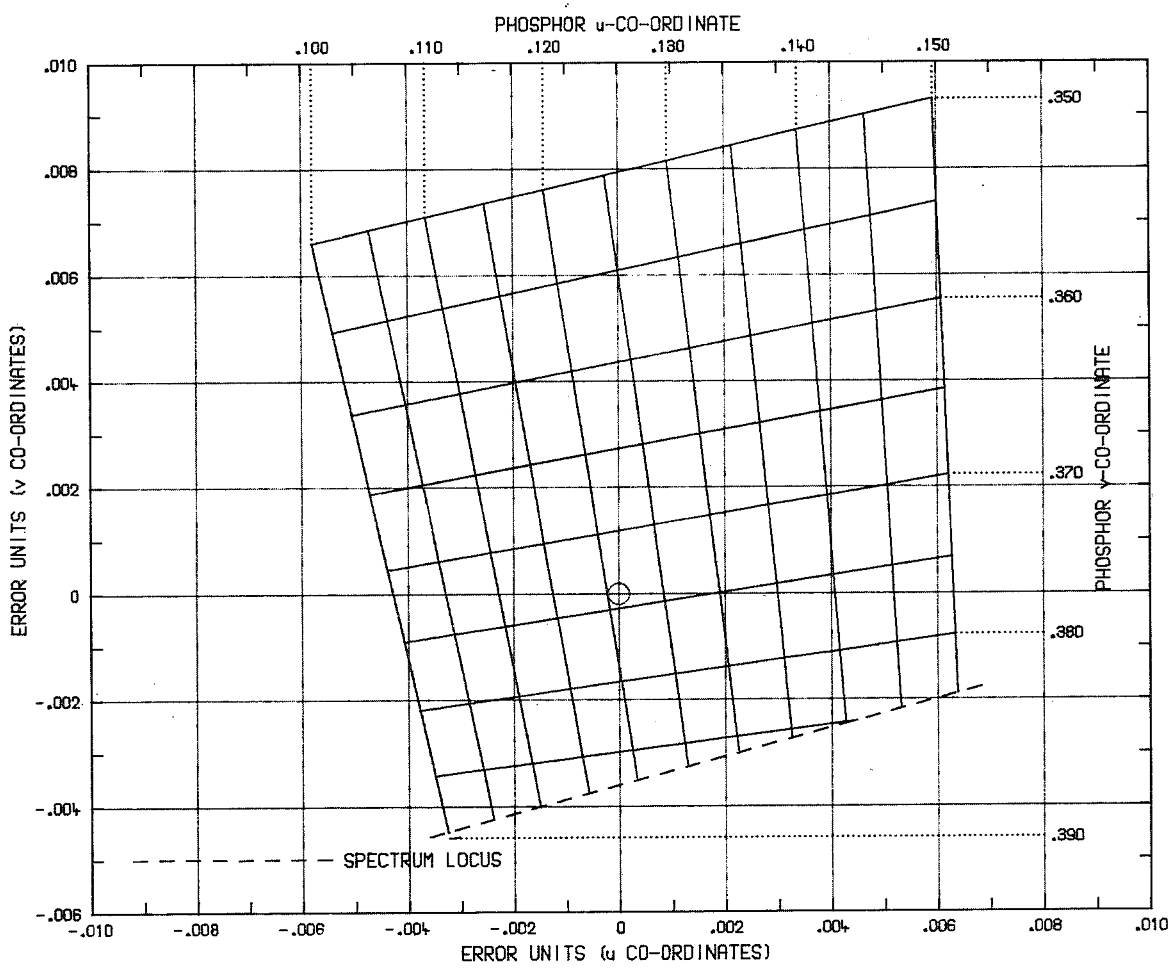


Diagram CIE 6/R
Test Colour CIE 6
Red Phosphor



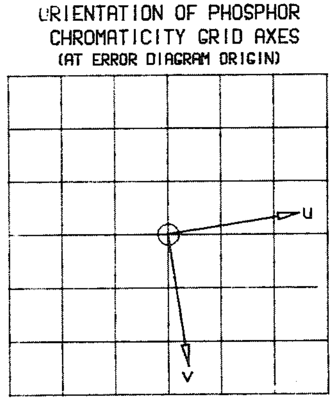
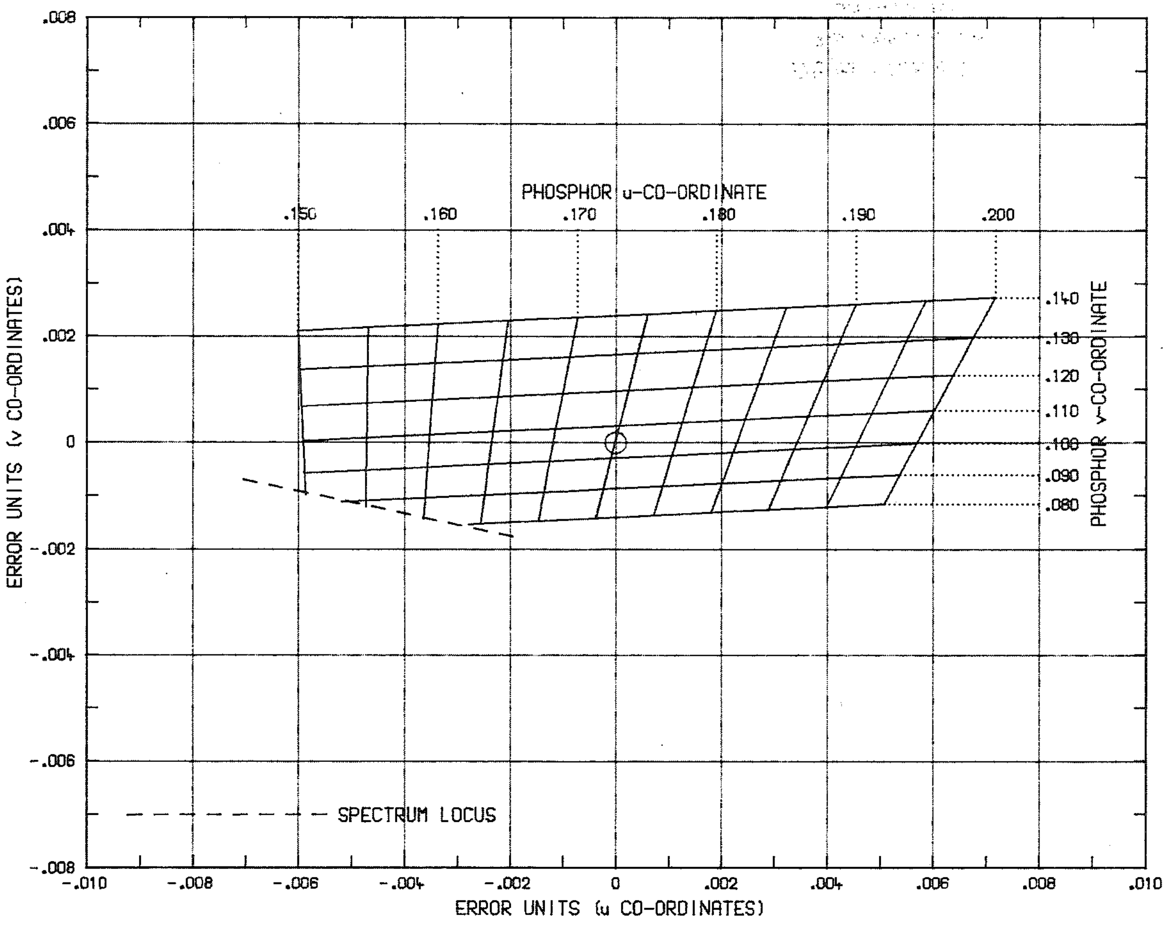


Diagram CIE 6/G
Test Colour CIE 6
Green Phosphor



ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

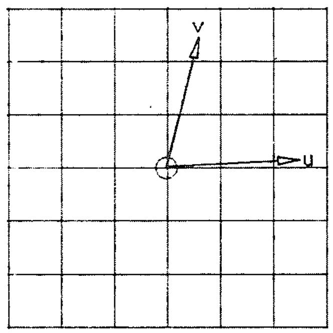
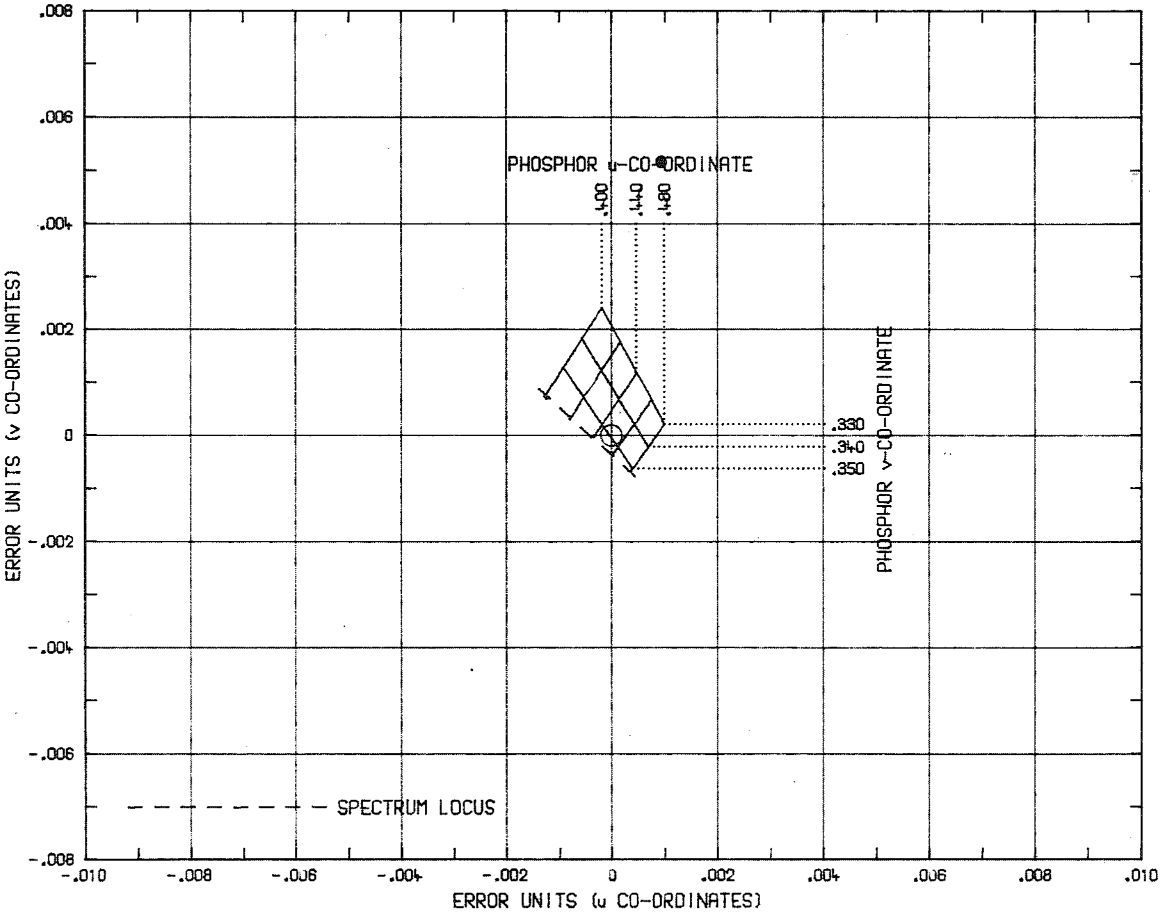


Diagram CIE 6/B
Test Colour CIE 6
Blue Phosphor



ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

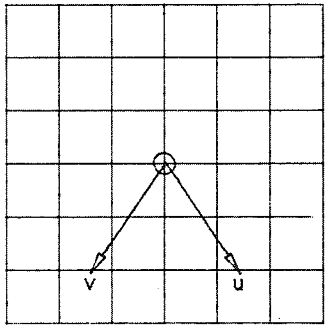
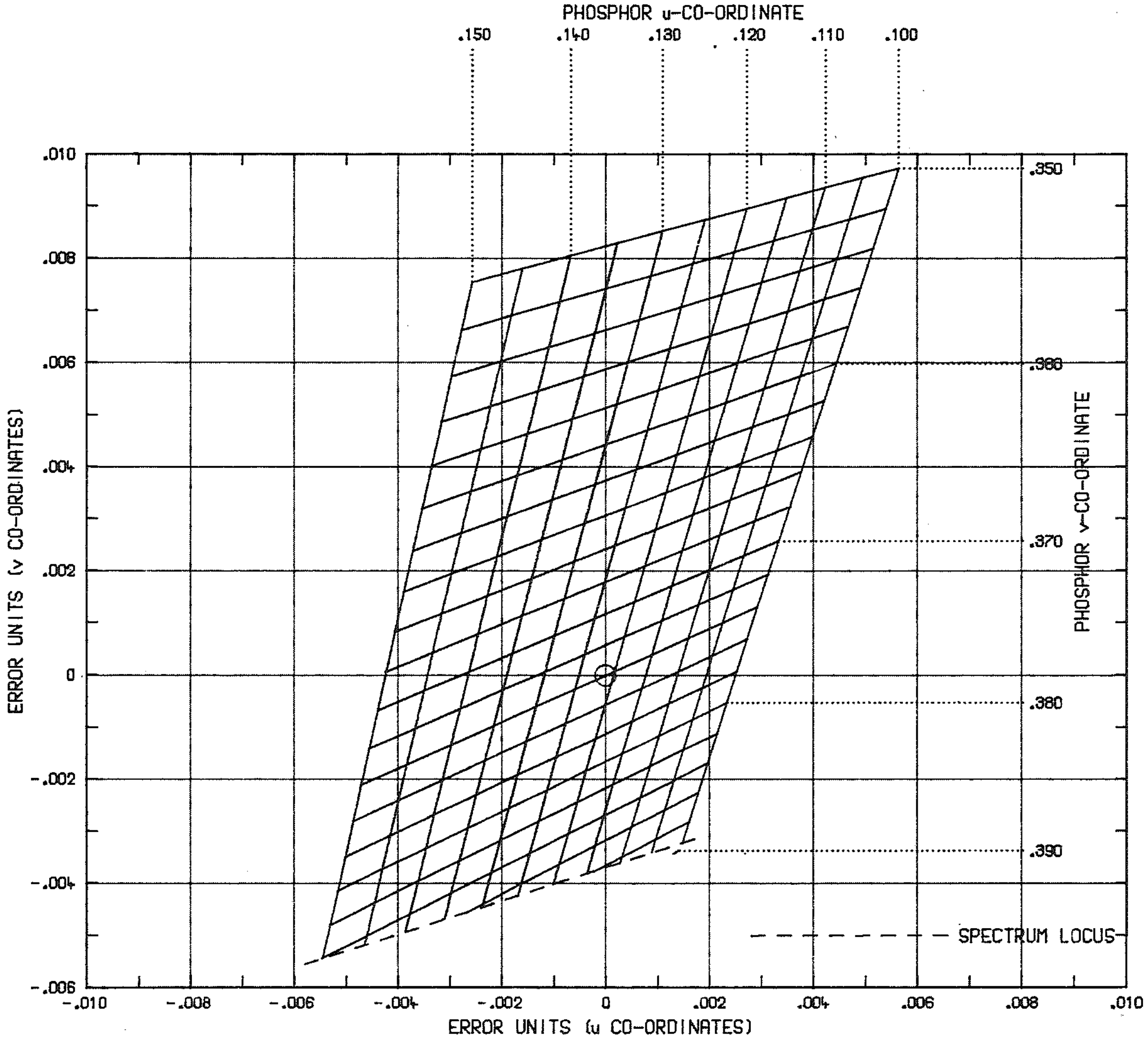


Diagram CIE 7/R
Test Colour CIE 7
Red Phosphor



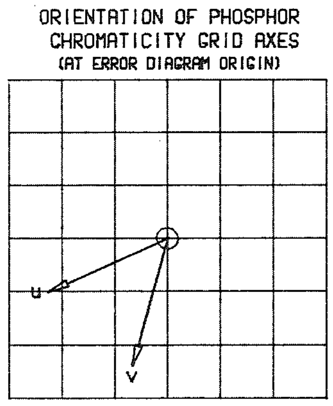


Diagram CIE 7/G
Test Colour CIE 7
Green Phosphor

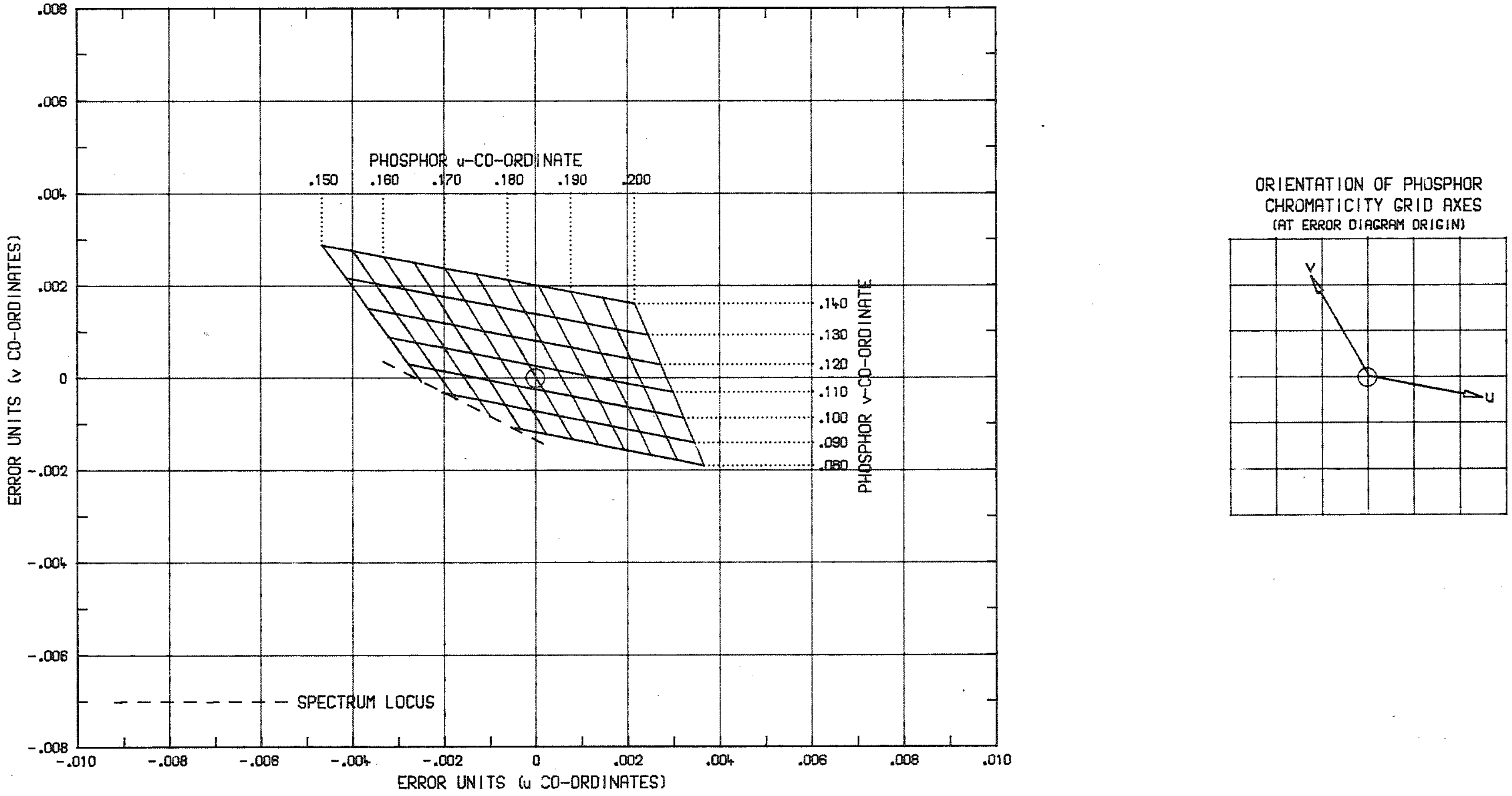
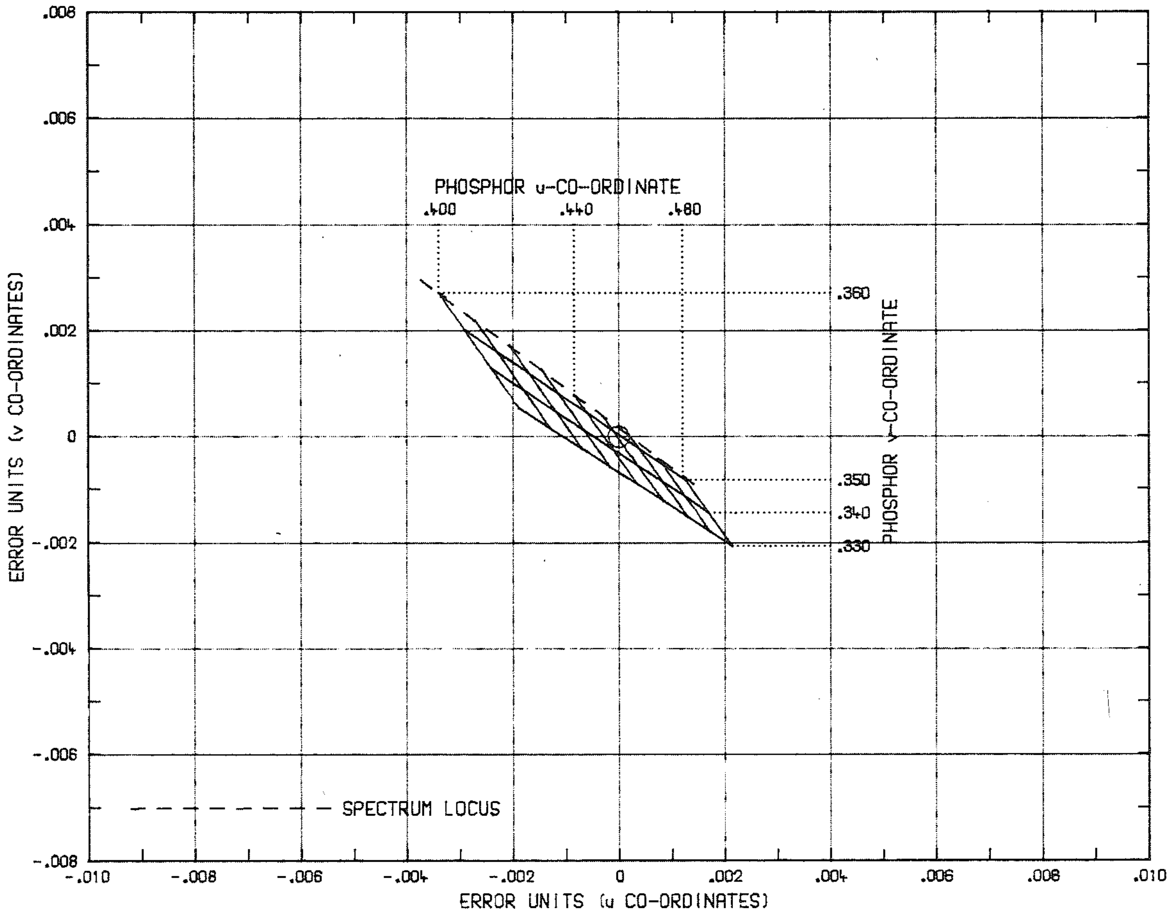


Diagram CIE 7/B
Test Colour CIE 7
Blue Phosphor



ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

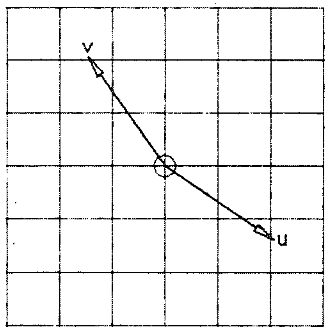
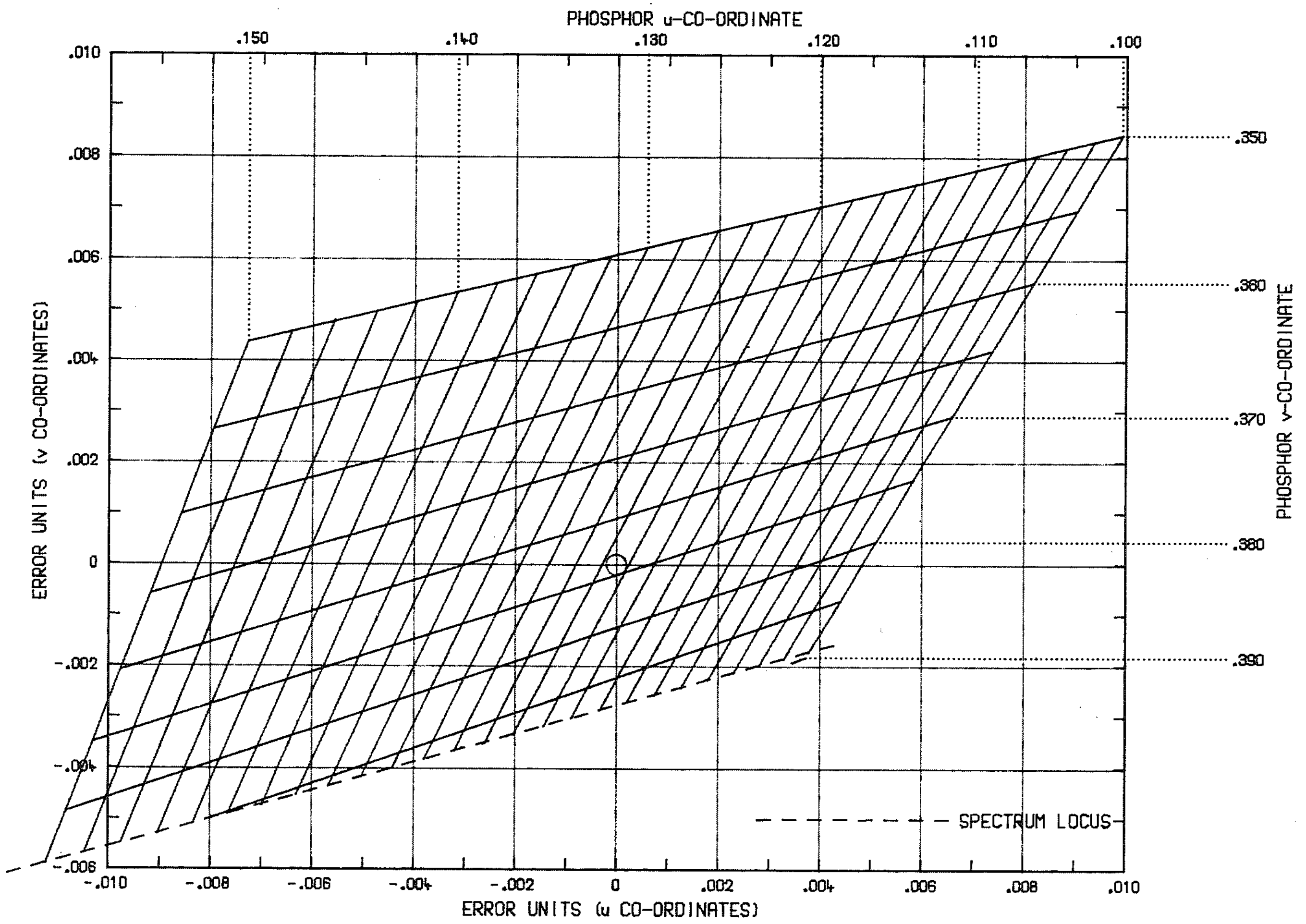


Diagram CIE 8/R
Test Colour CIE 8
Red Phosphor



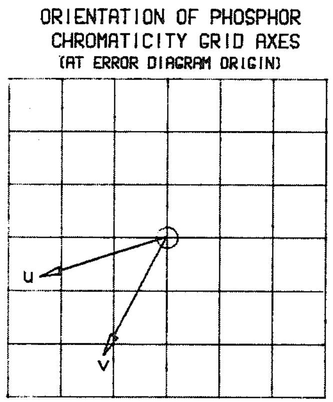
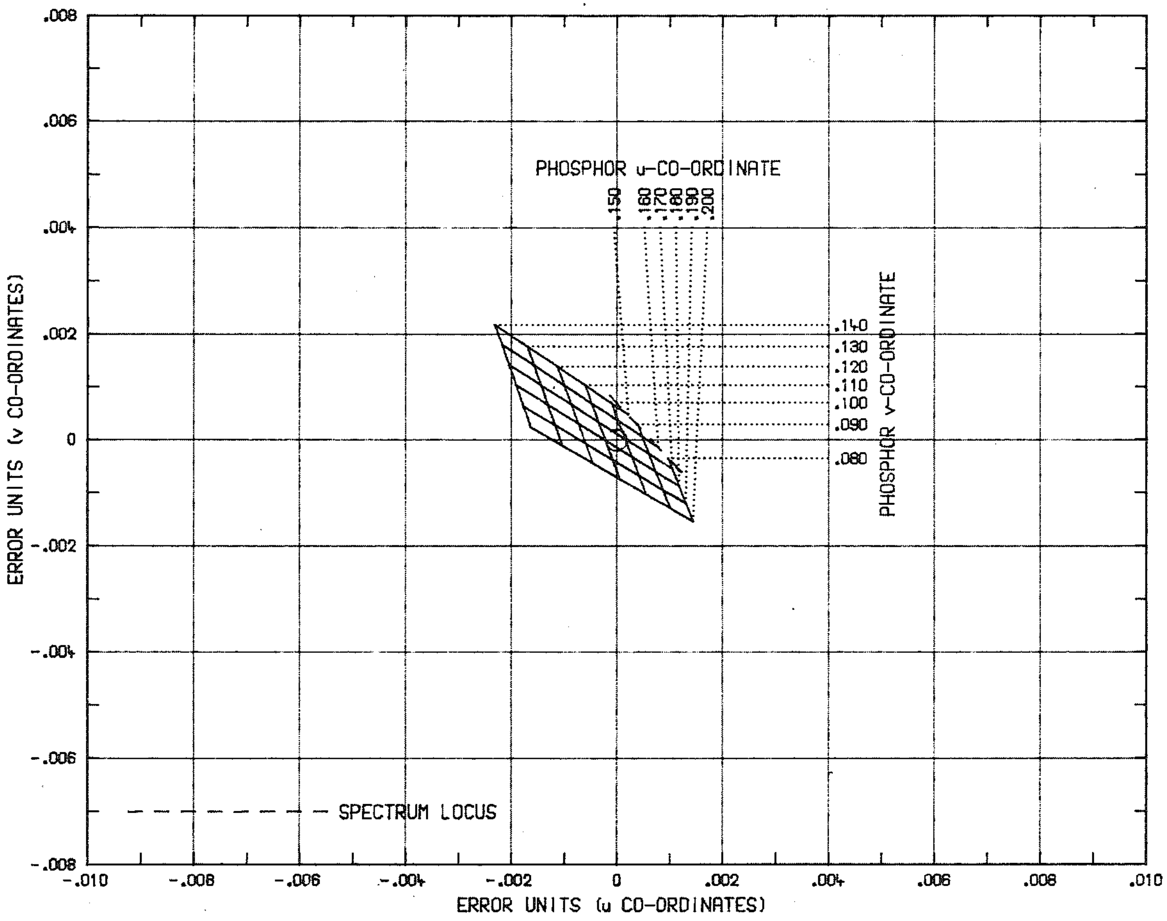


Diagram CIE 8/G
Test Colour CIE 8
Green Phosphor



ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

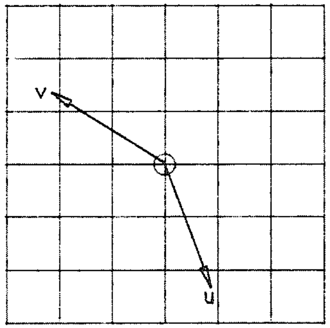
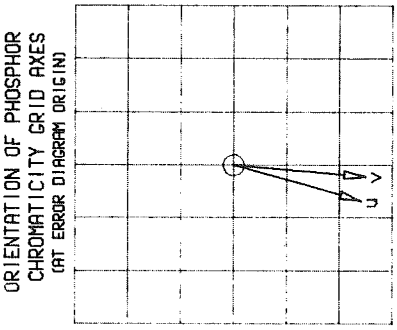


Diagram CIE 8/B
Test Colour CIE 8
Blue Phosphor



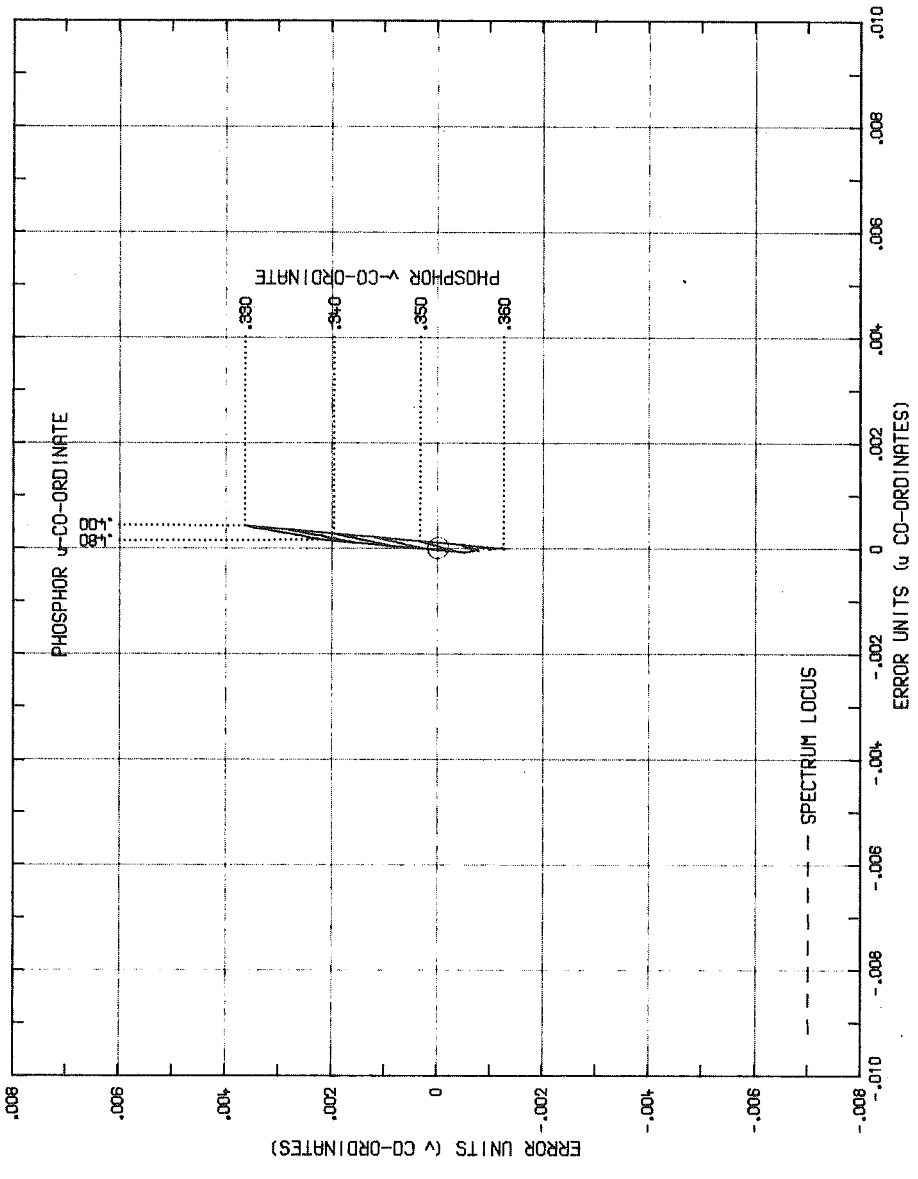
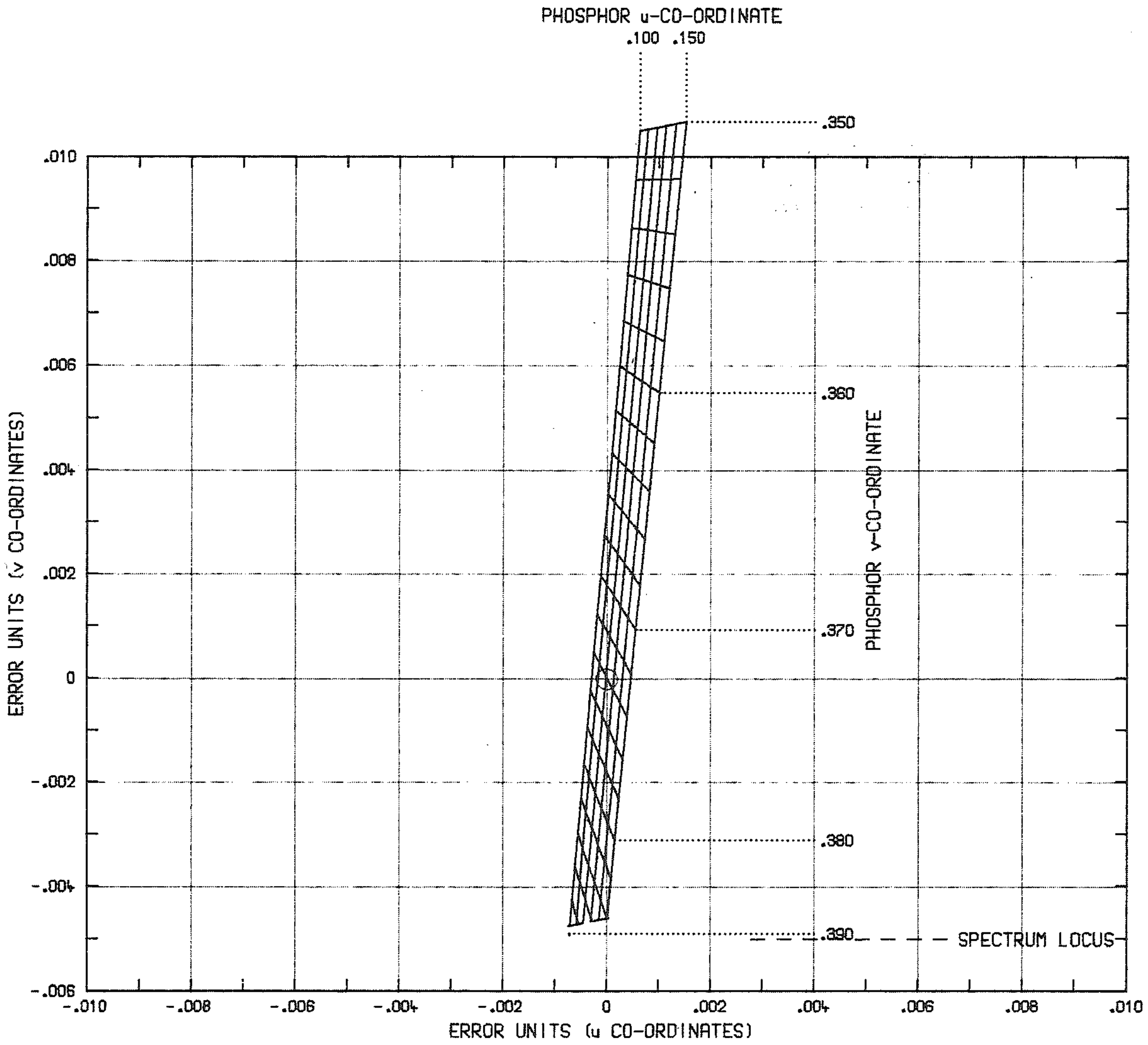


Diagram BBC 9(M)/R
Test Colour BBC 9(M)
Red Phosphor



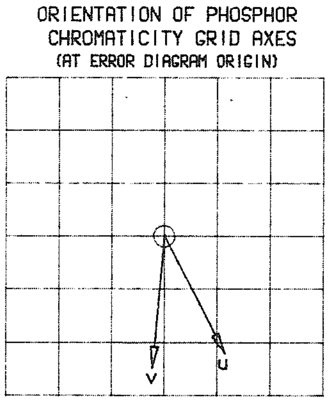
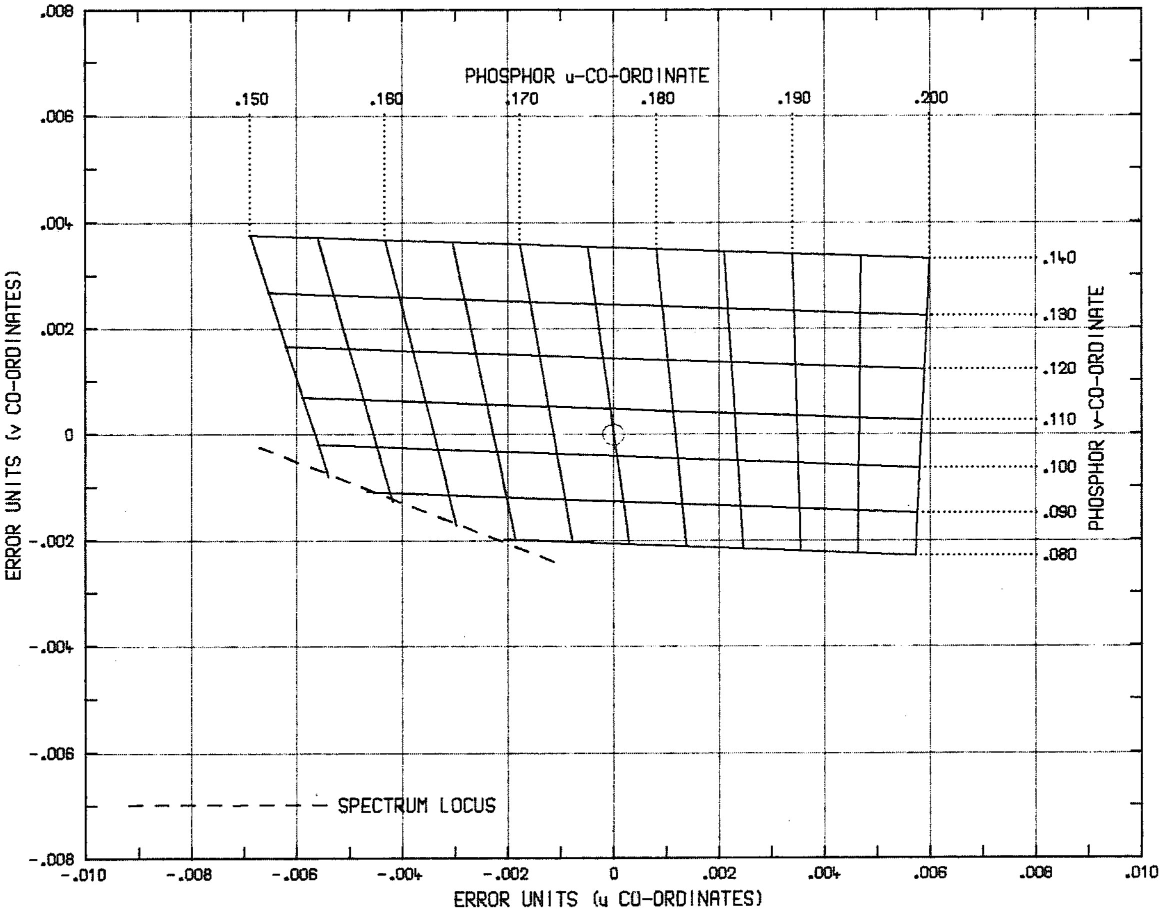


Diagram BBC 9(M)/G
Test Colour BBC 9(M)
Green Phosphor



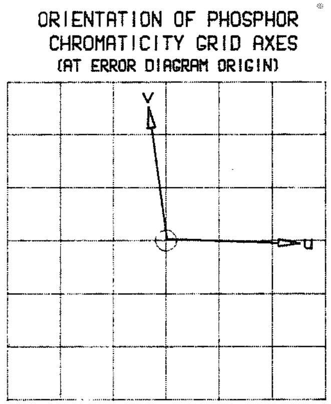
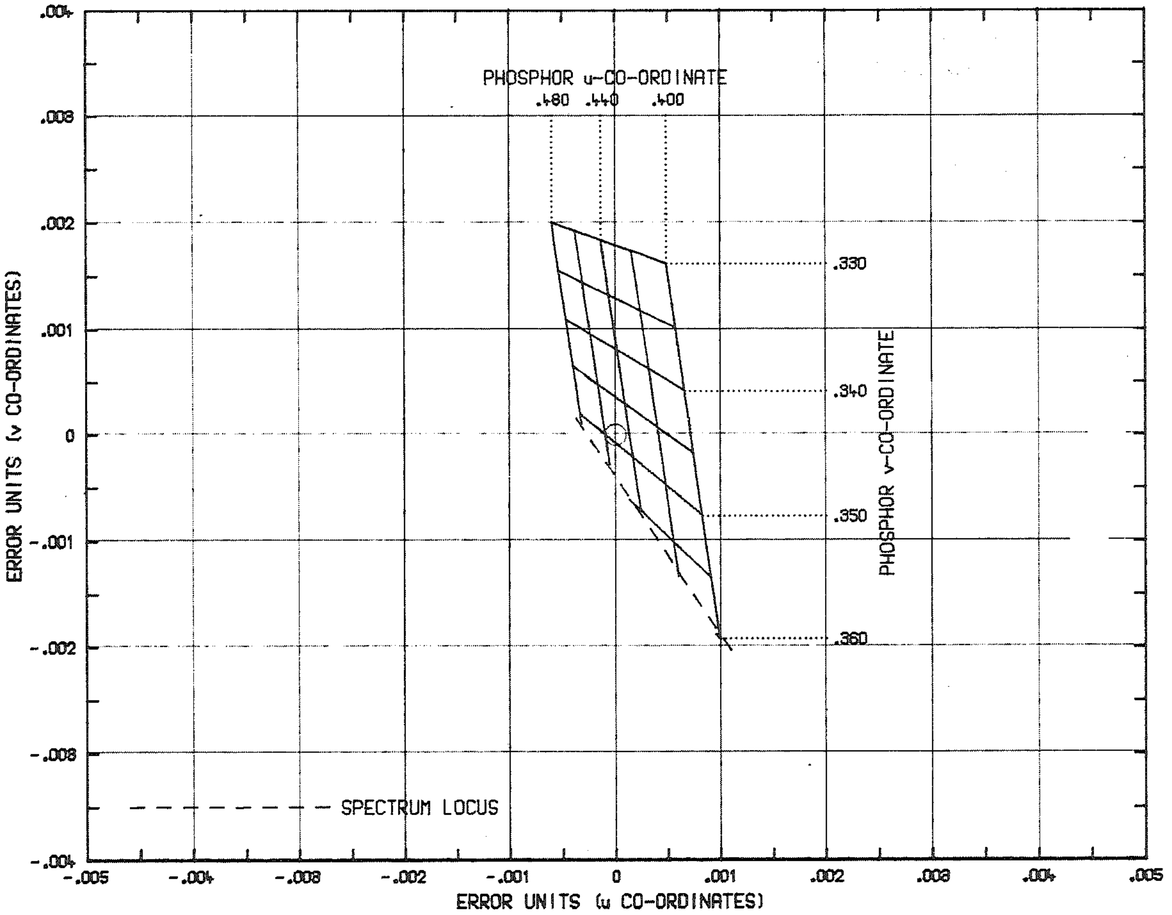


Diagram BBC 9(M)/B
Test Colour BBC 9(M)
Blue Phosphor



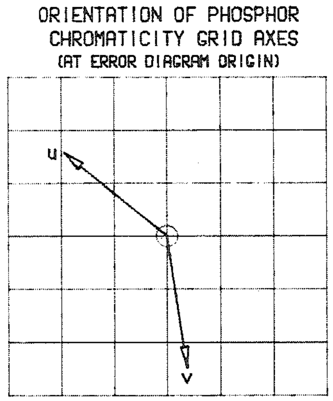
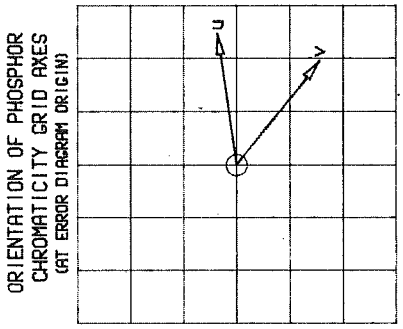


Diagram BBC 10/R
Test Colour BBC 10
Red Phosphor


ORIENTATION OF PHOSPHOR CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)
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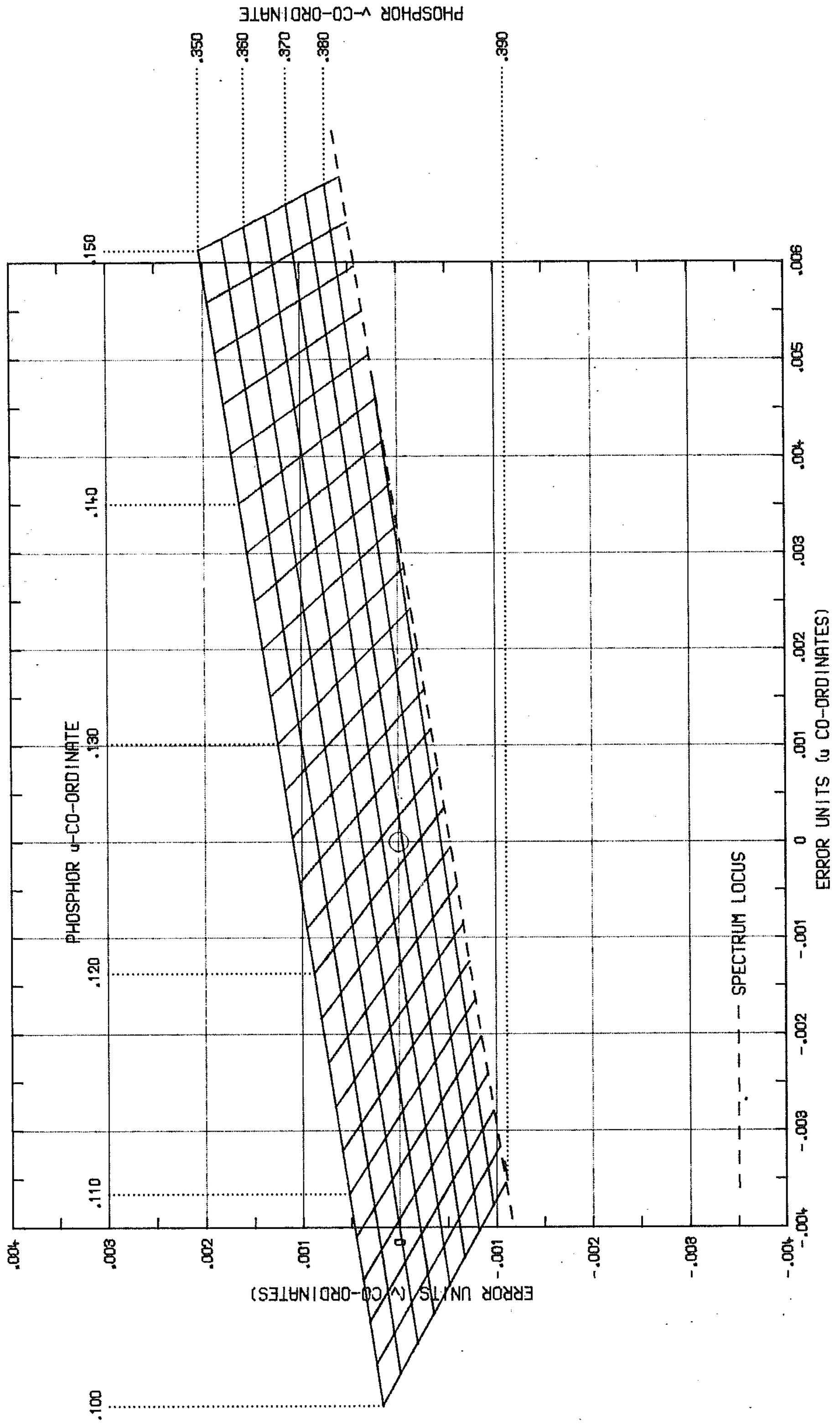
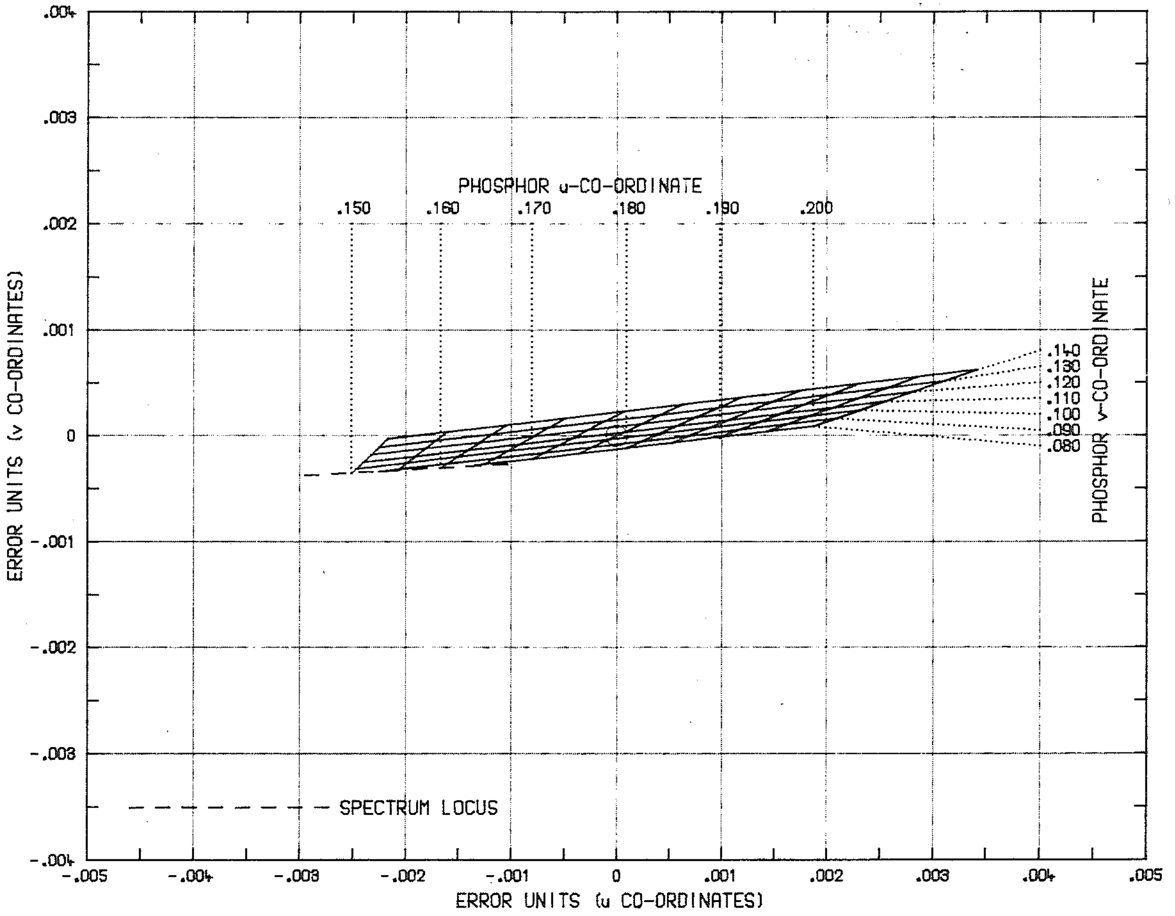


Diagram BBC 10/G

Test Colour BBC 10

Green Phosphor



ORIENTATION OF PHOSPHOR CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

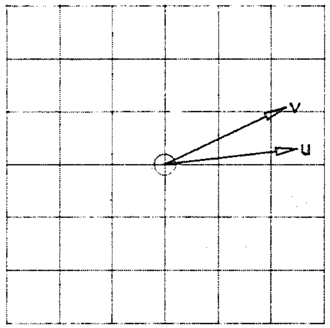
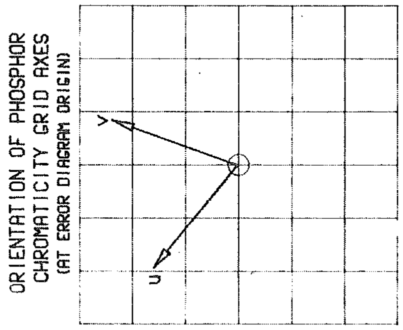


Diagram BBC 10/B
Test Colour BBC 10
Blue Phosphor



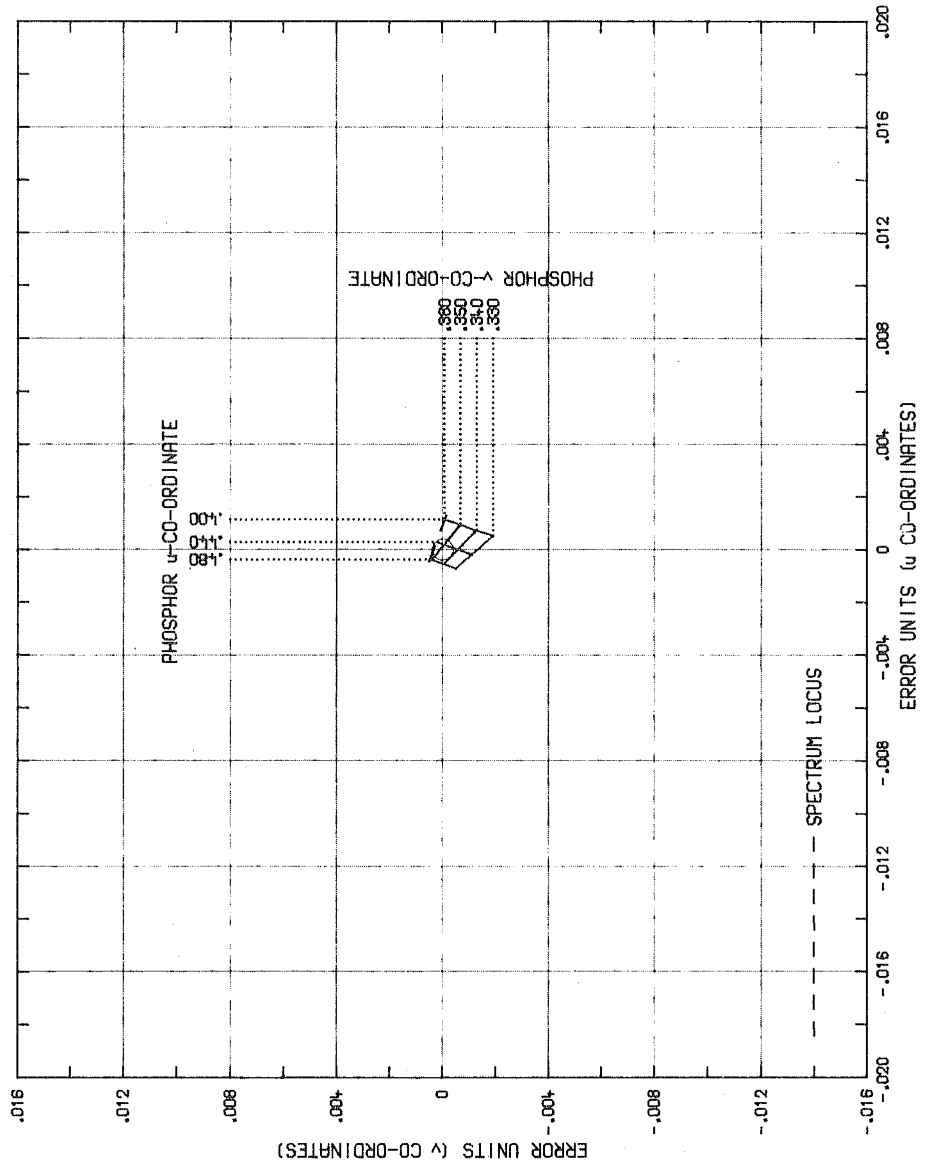


Diagram BBC 11/R
Test Colour BBC 11
Red Phosphor

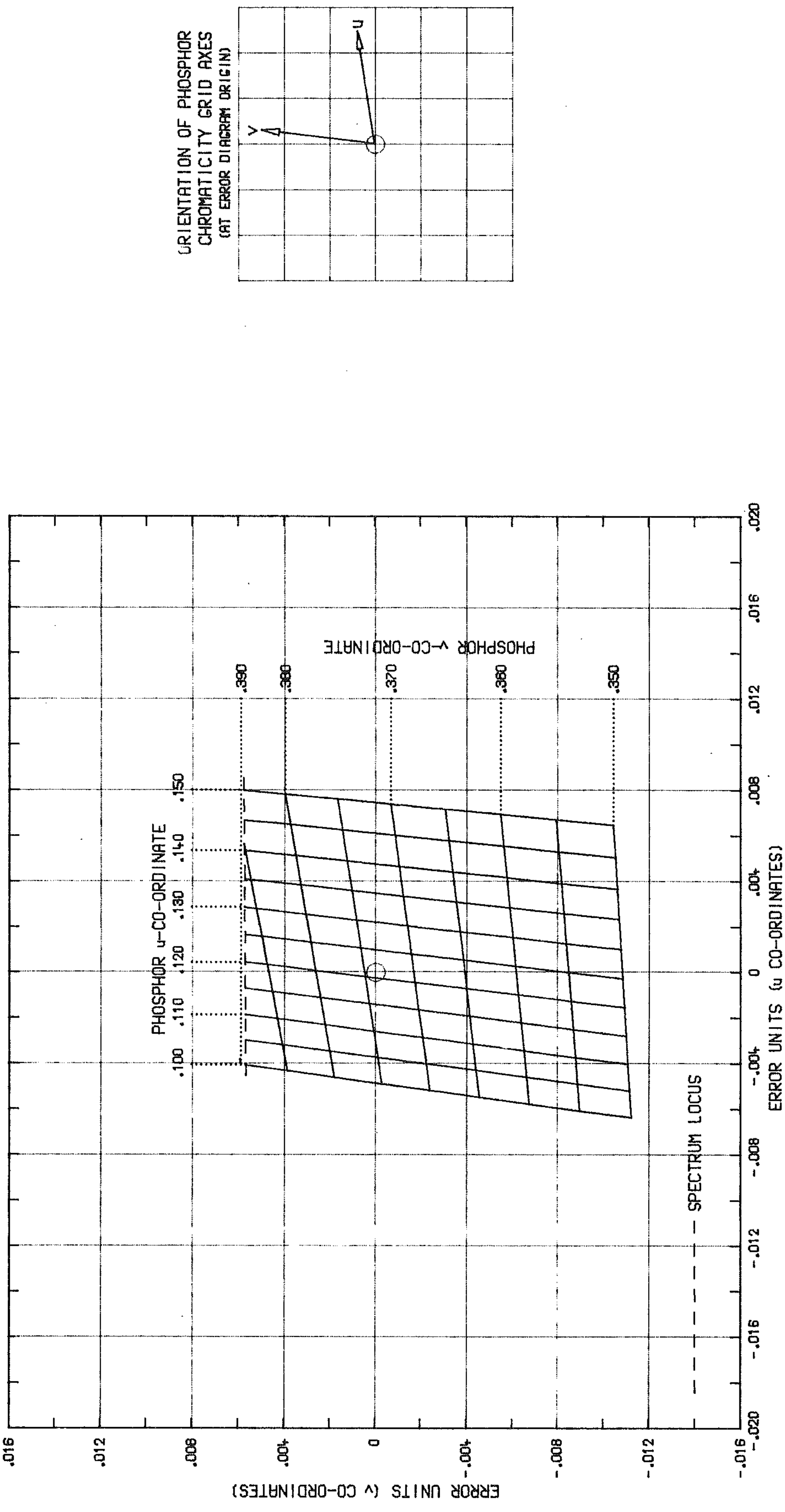
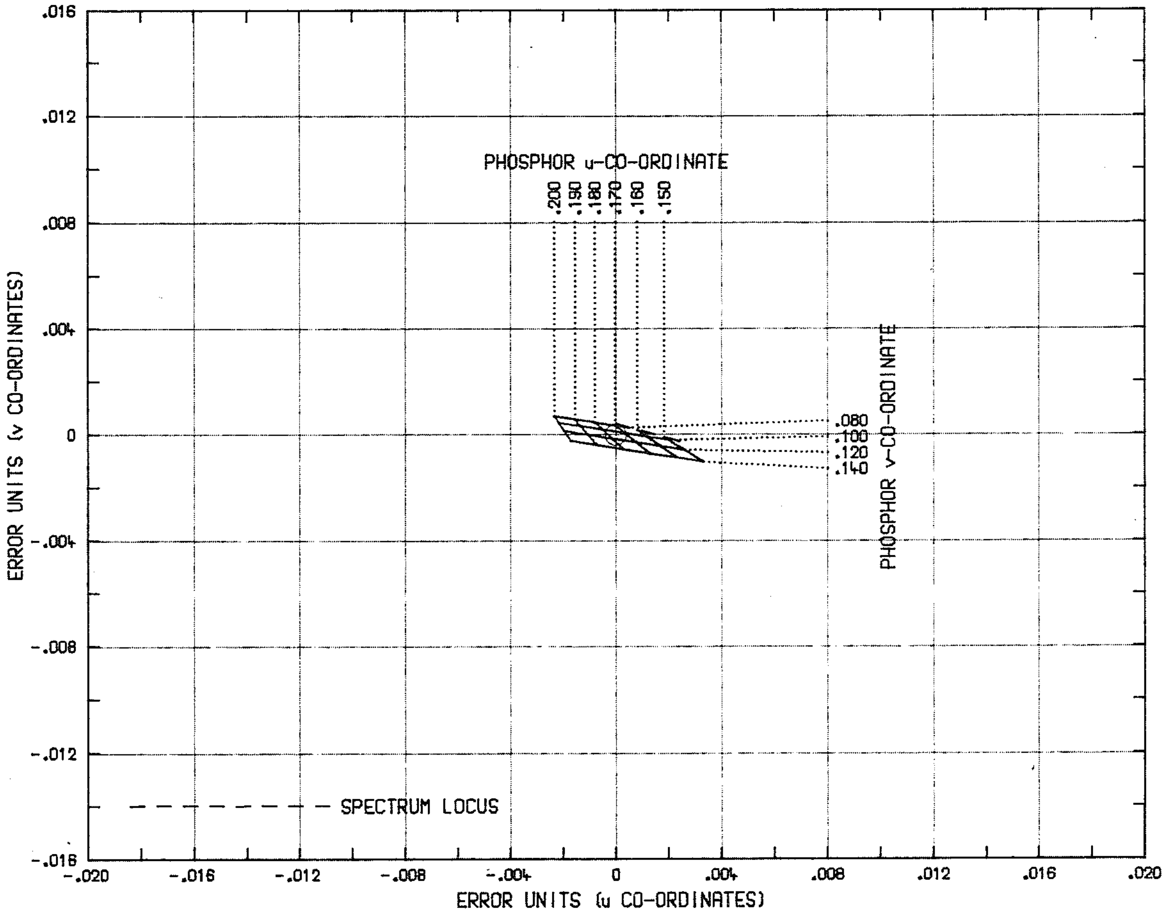


Diagram BBC 11/G
Test Colour BBC 11
Green Phosphor



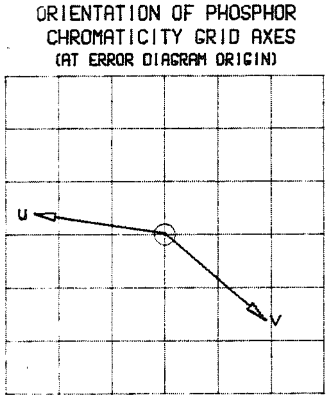
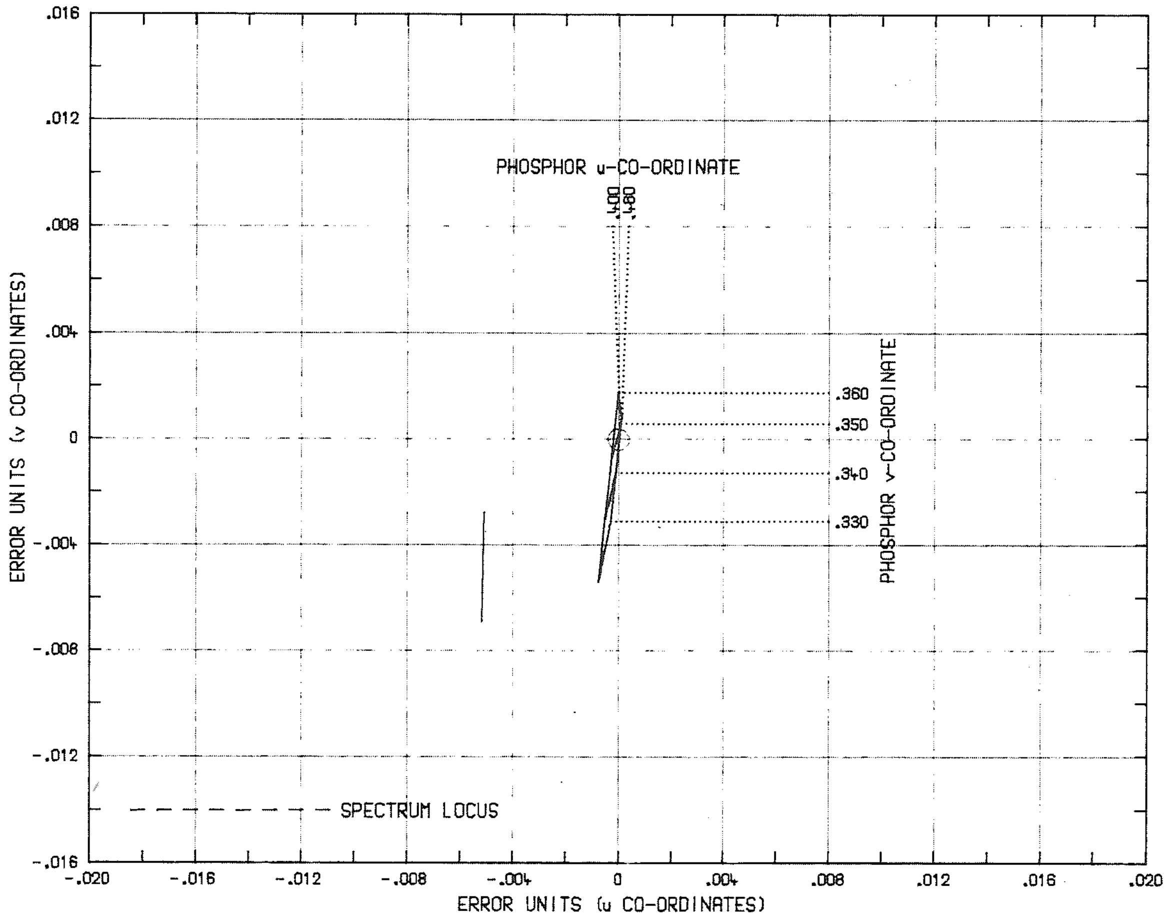


Diagram BBC 11/B
Test Colour BBC 11
Blue Phosphor



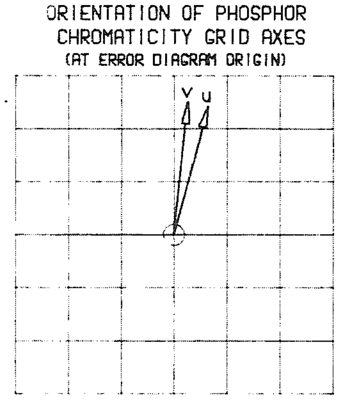
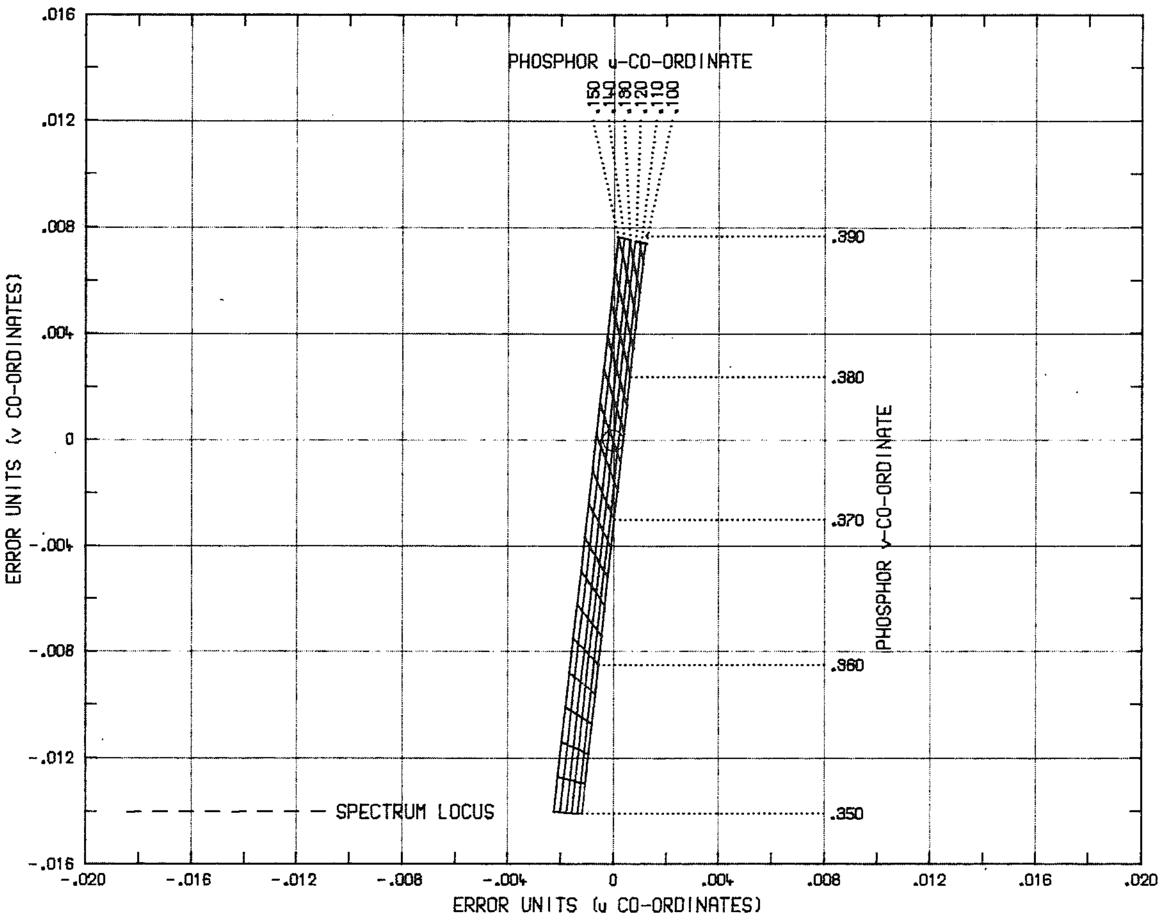


Diagram BBC 12/R
Test Colour BBC 12
Red Phosphor



ORIENTATION OF PHOSPHOR
CHROMATICITY GRID AXES
(AT ERROR DIAGRAM ORIGIN)

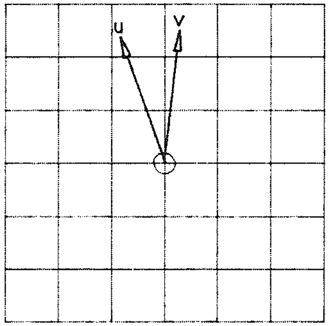


Diagram BBC 12/G
Test Colour BBC 12
Green Phosphor

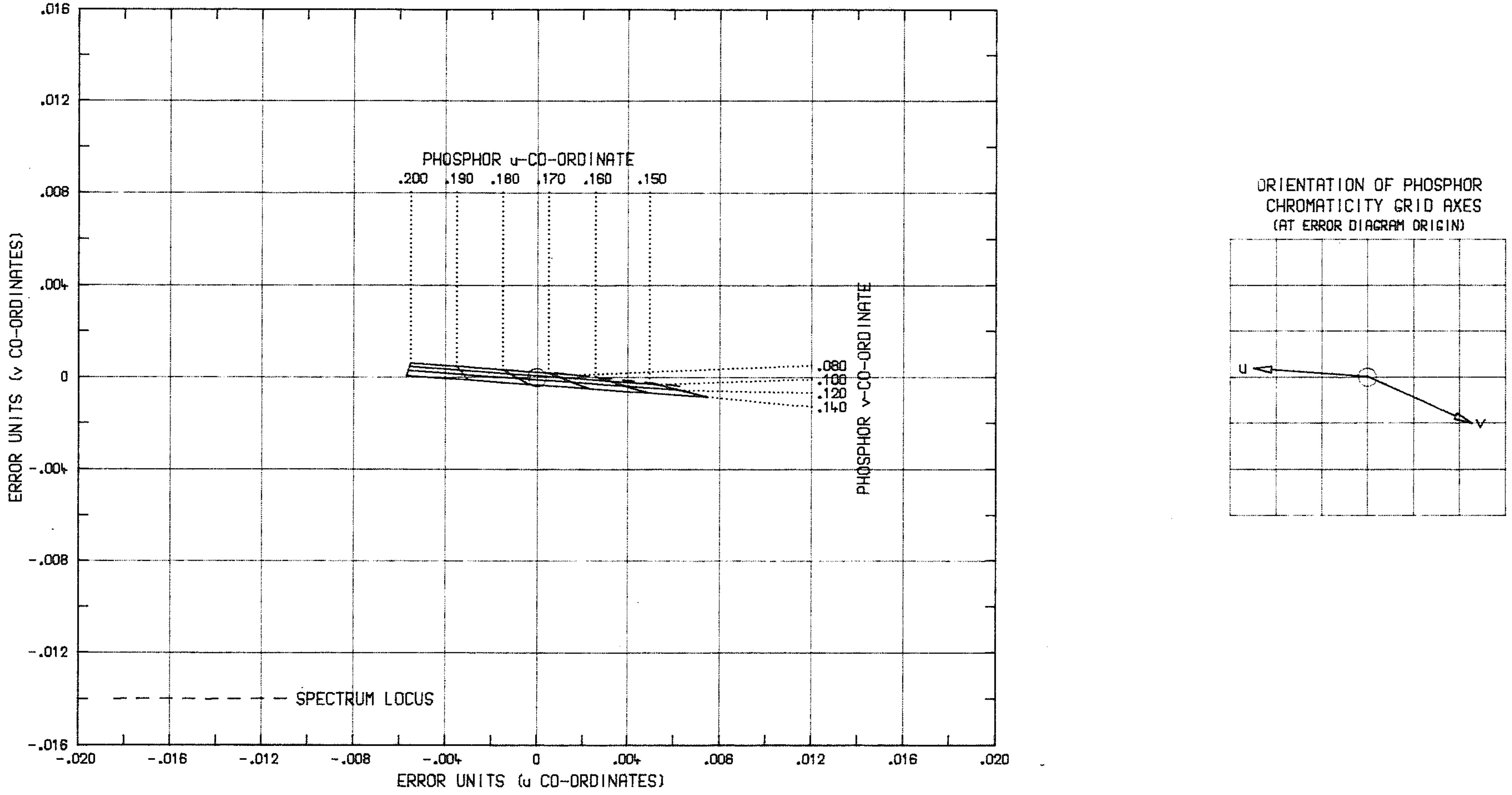
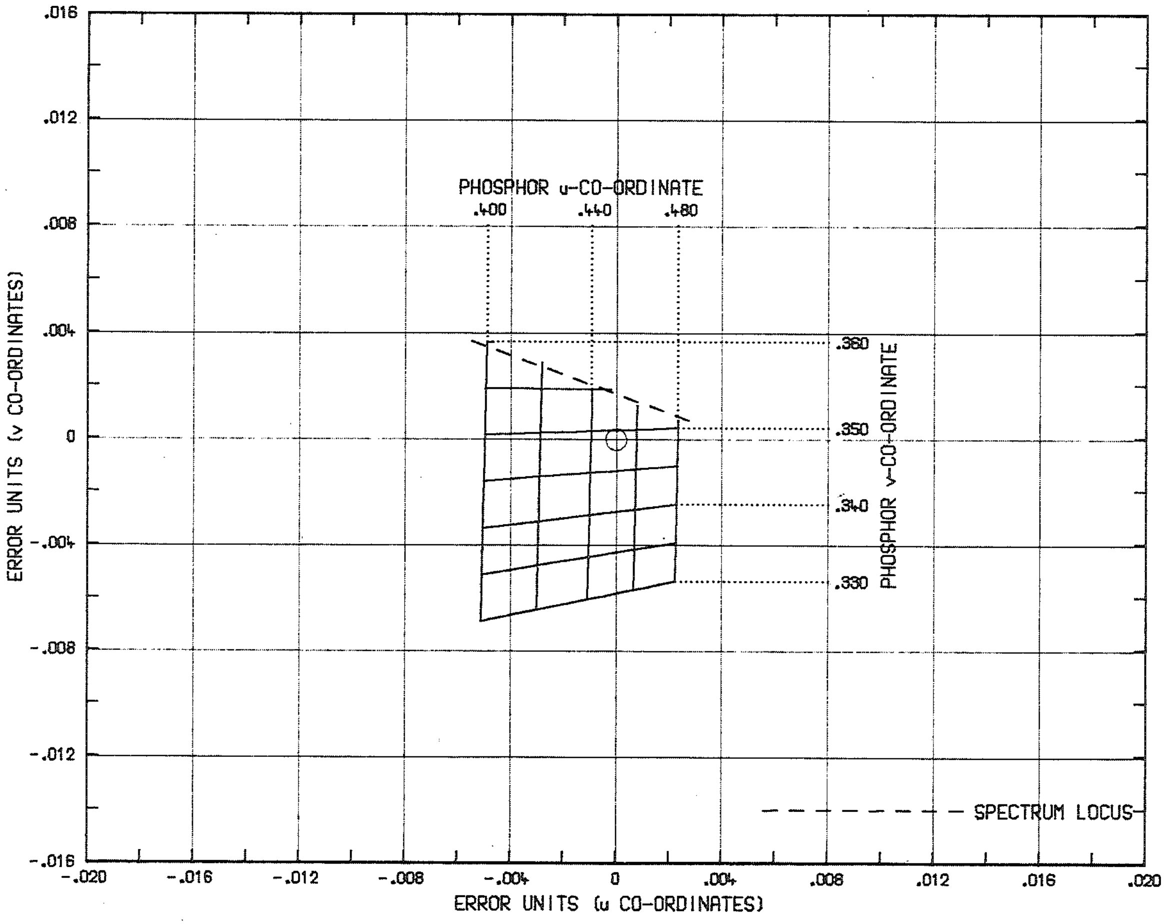


Diagram BBC 12/B

Test Colour BBC 12

Blue Phosphor



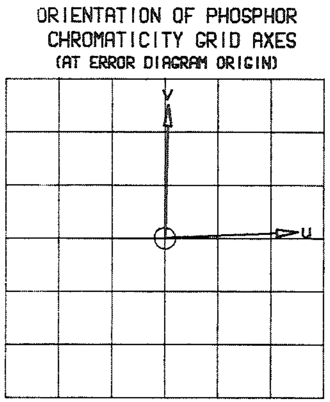
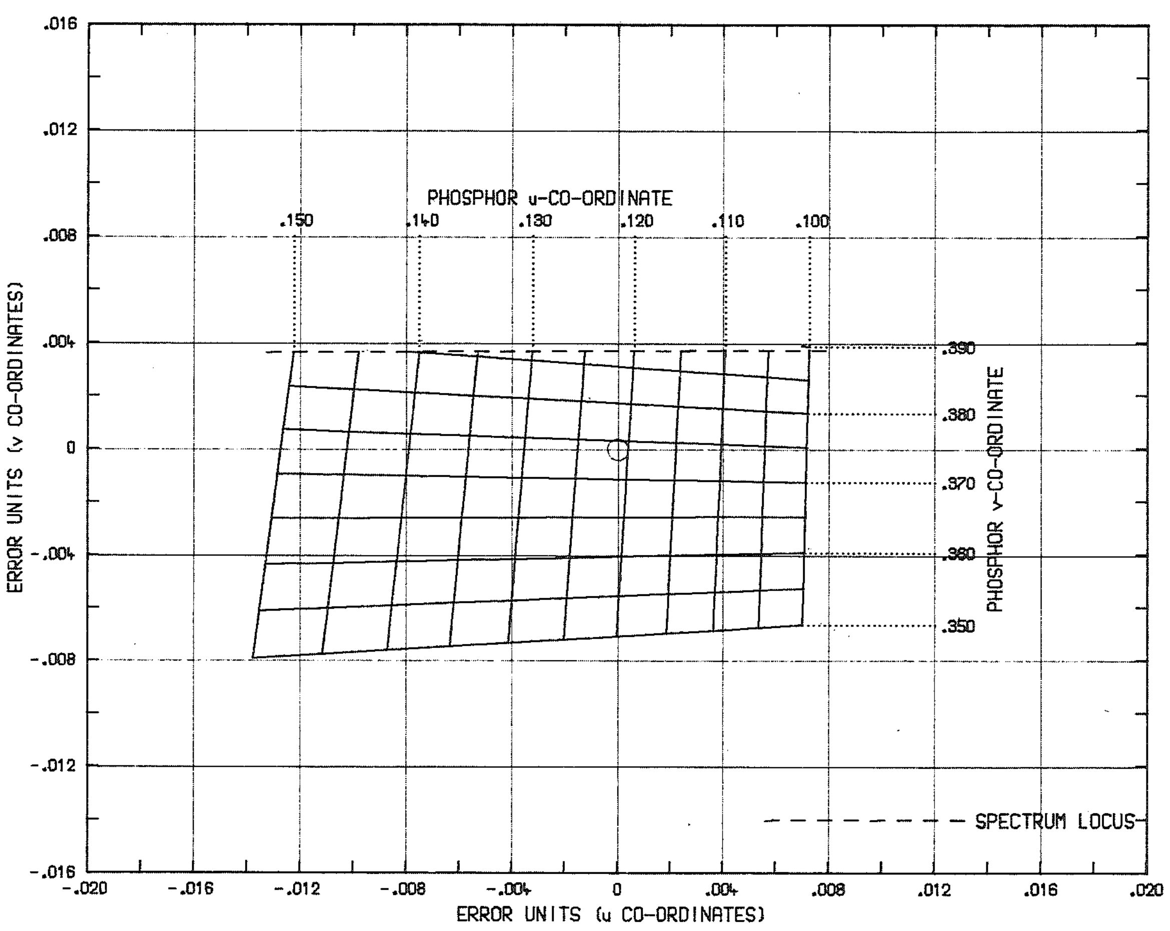


Diagram BBC 13/R
Test Colour BBC 13
Red Phosphor



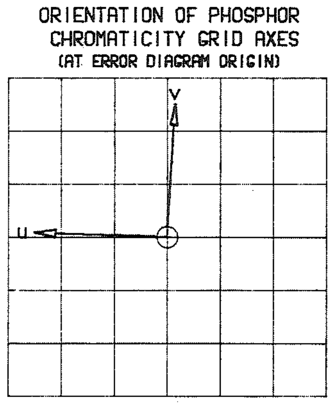
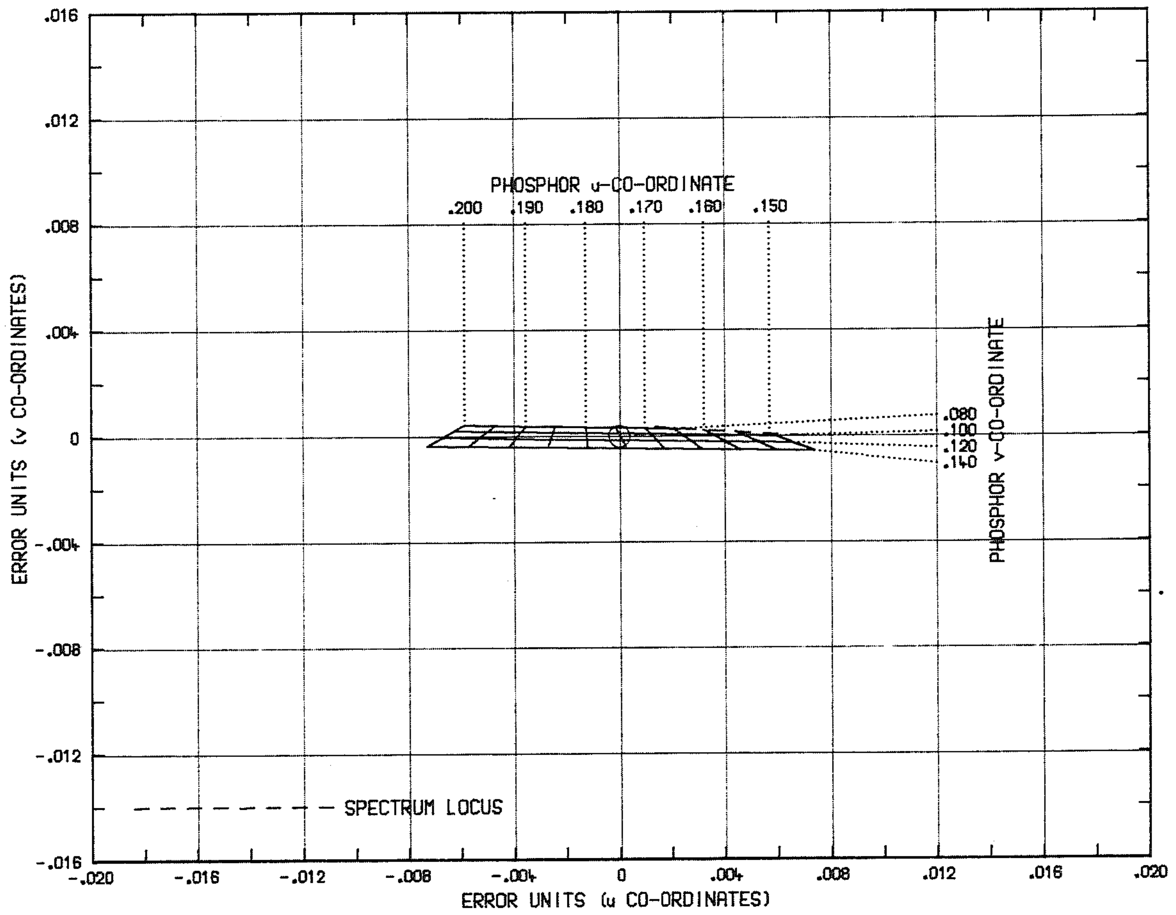


Diagram BBC 13/G
Test Colour BBC 13
Green Phosphor



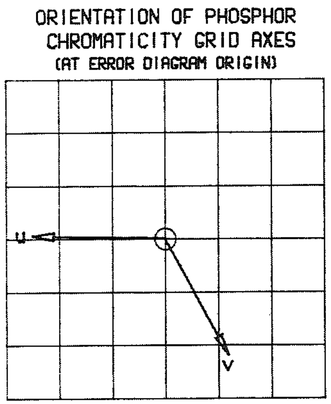


Diagram BBC 13/B
Test Colour BBC 13
Blue Phosphor

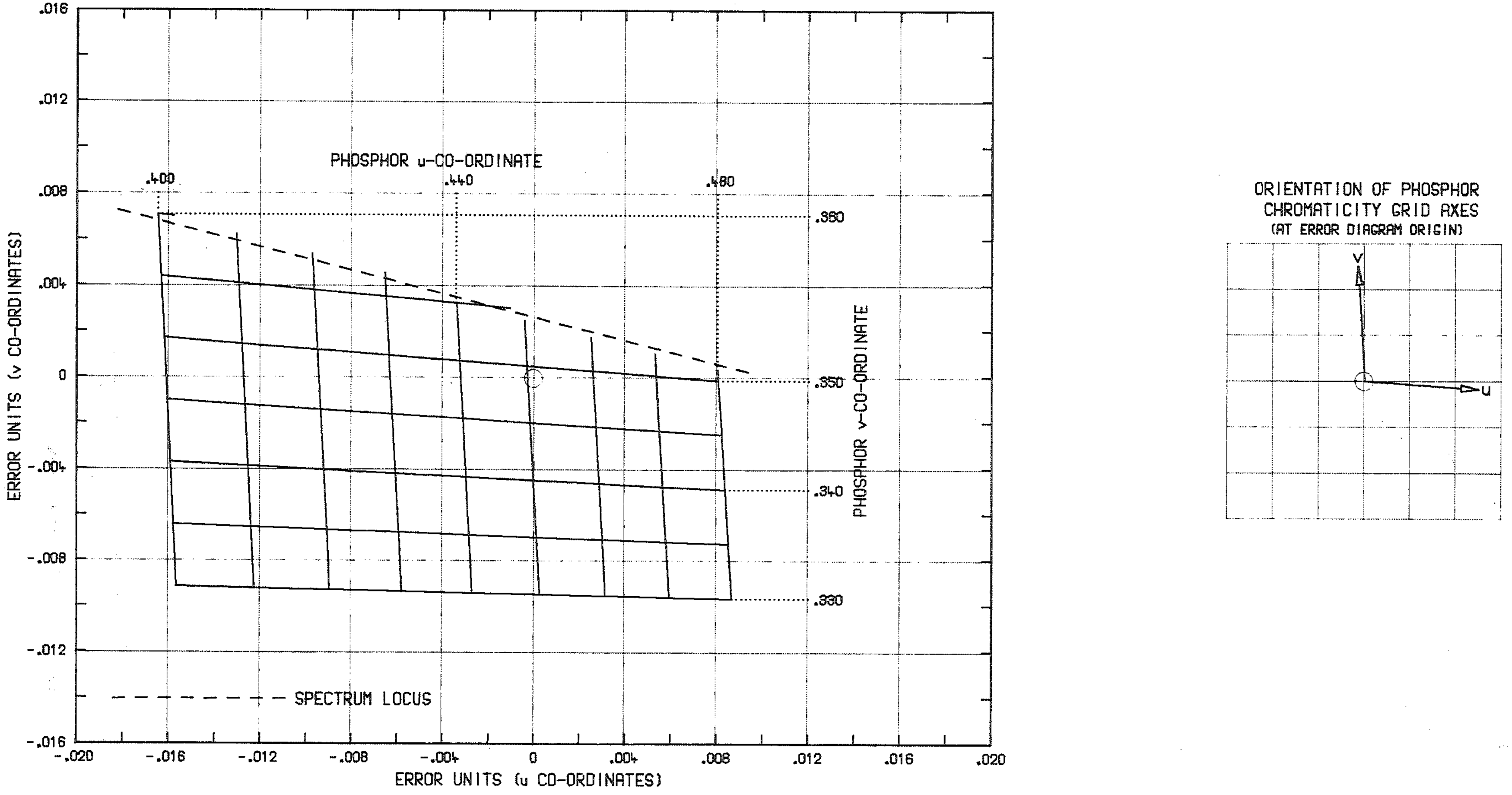
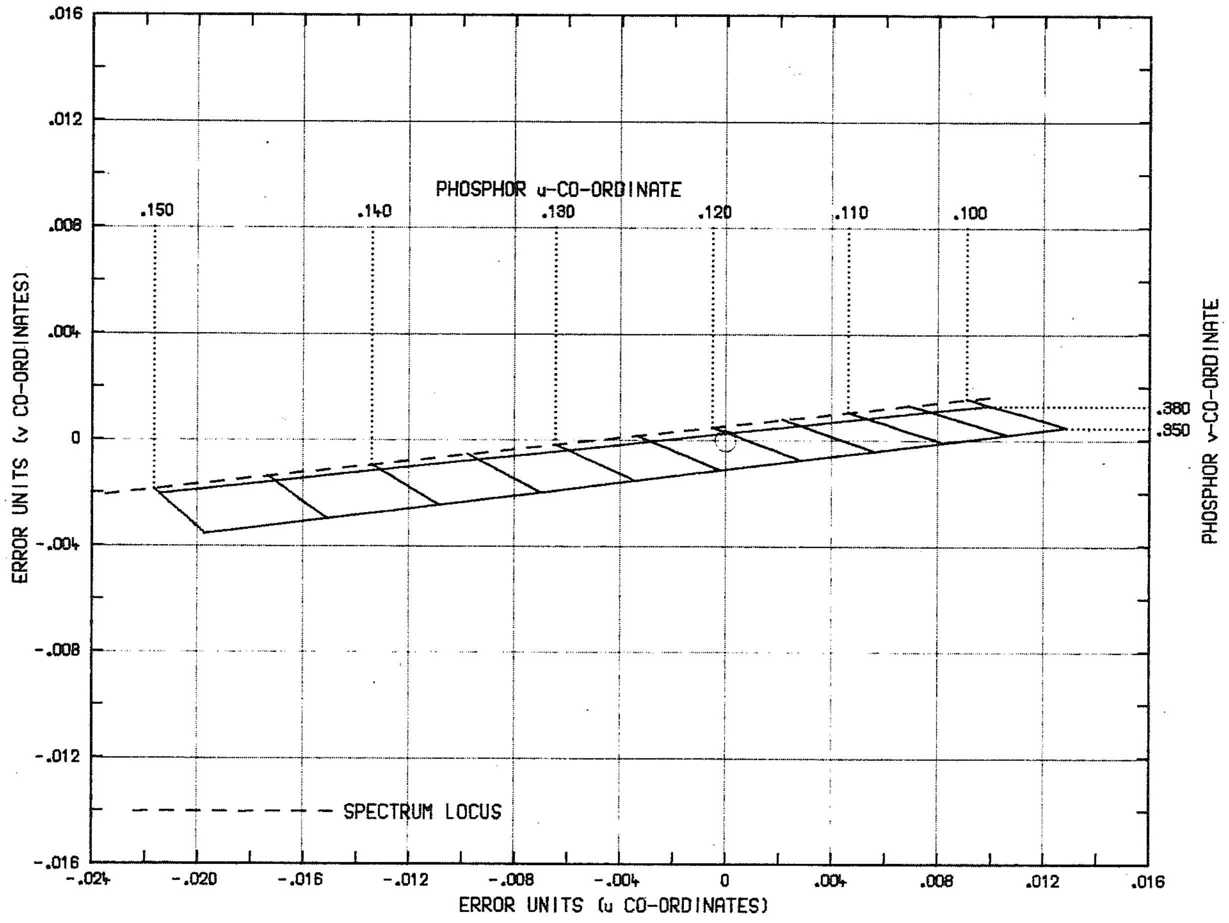


Diagram BBC 14(M)/R
Test Colour BBC 14(M)
Red Phosphor



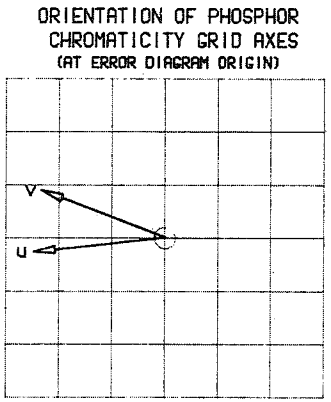


Diagram BBC 14(M)/G
Test Colour BBC 14(M)
Green Phosphor

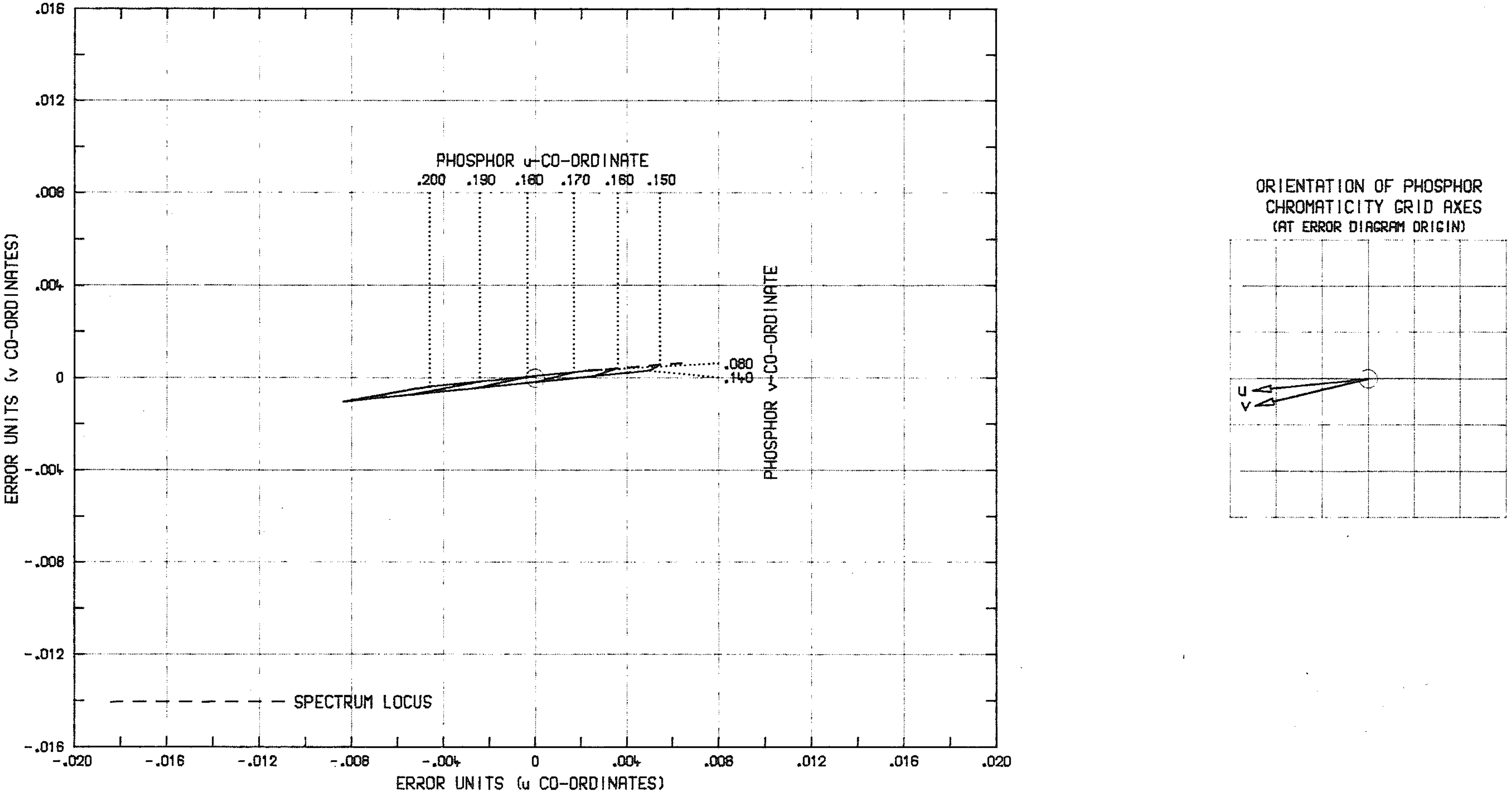
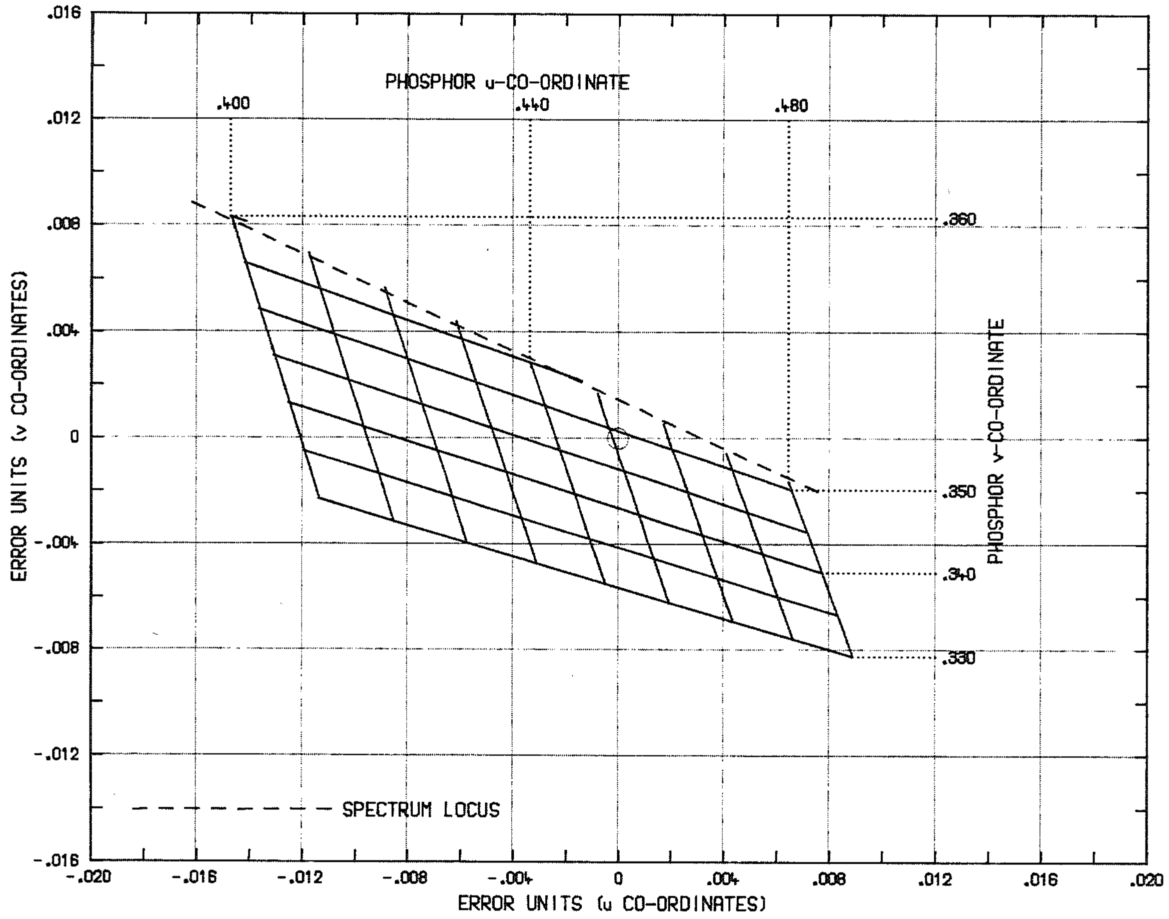


Diagram BBC 14(M)/B
Test Colour BBC 14(M)
Blue Phosphor



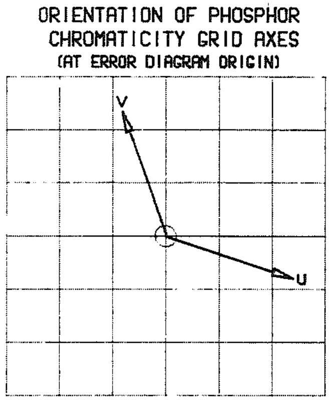


Diagram BBC 15/R
Test Colour BBC 15
Red Phosphor

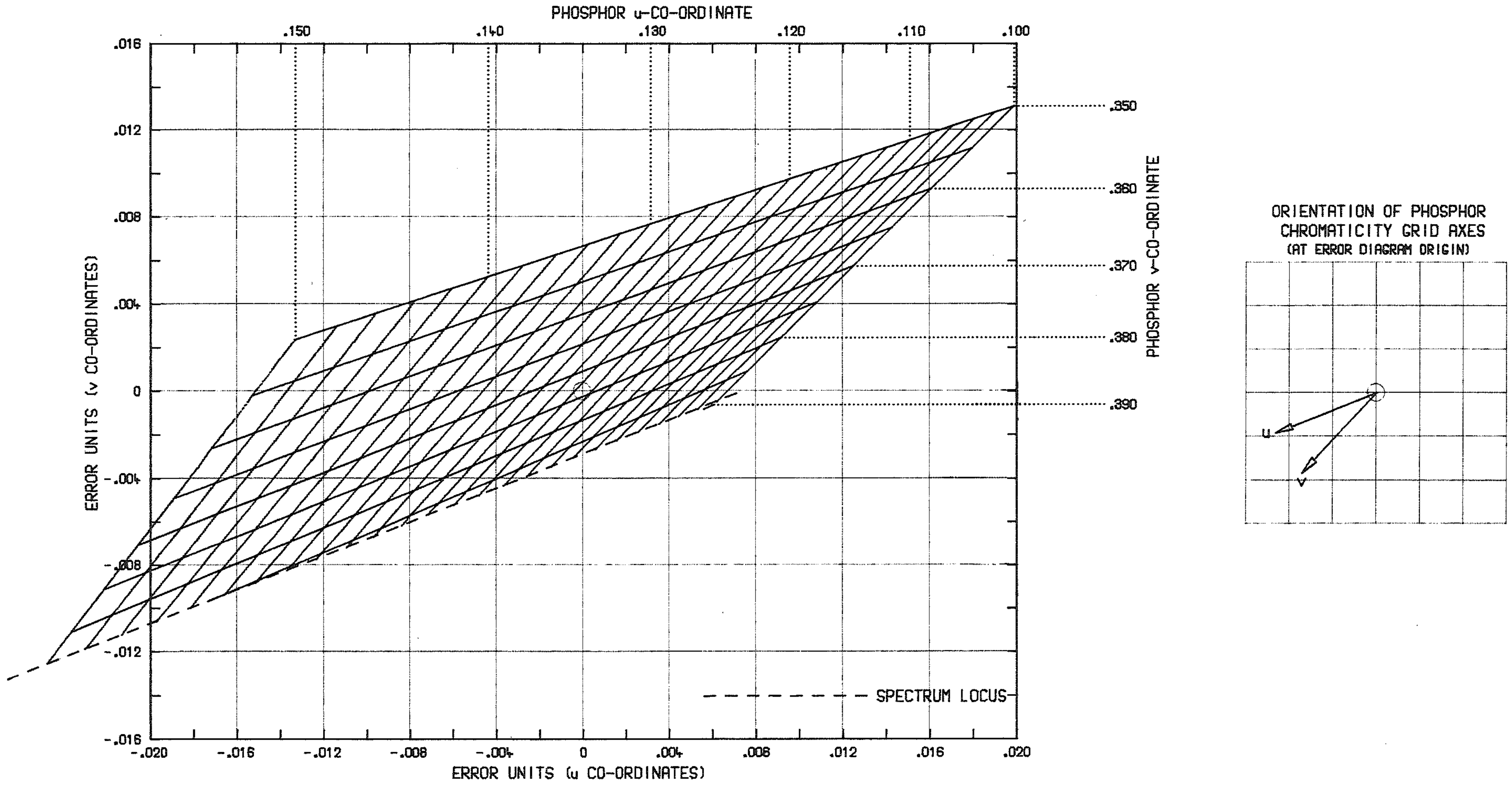
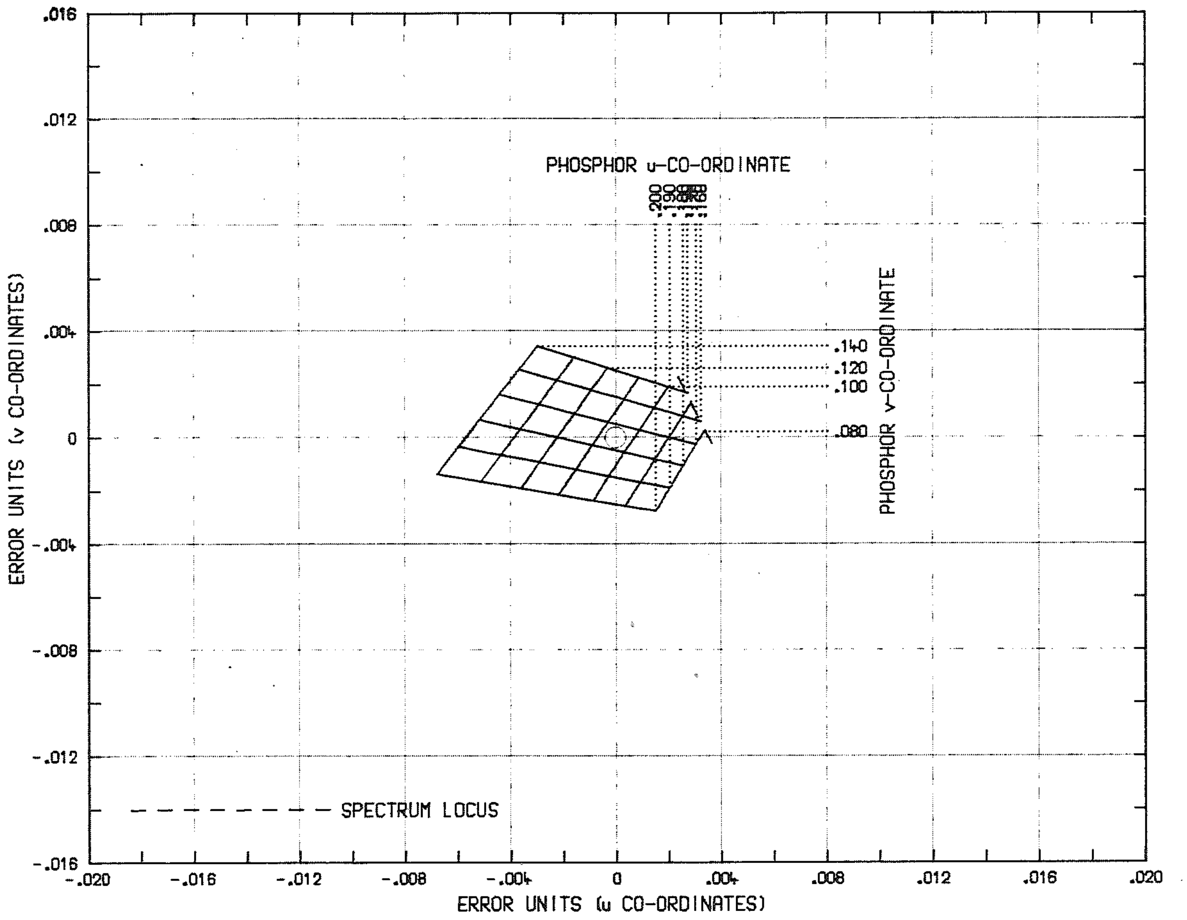


Diagram BBC 15/G
Test Colour BBC 15
Green Phosphor



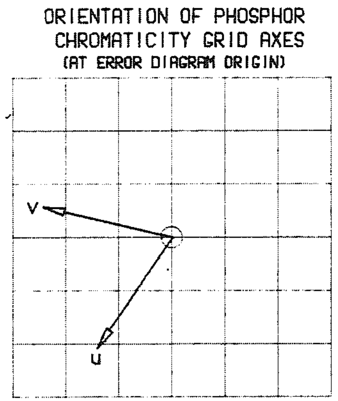


Diagram BBC 15/B
Test Colour BBC 15
Blue Phosphor

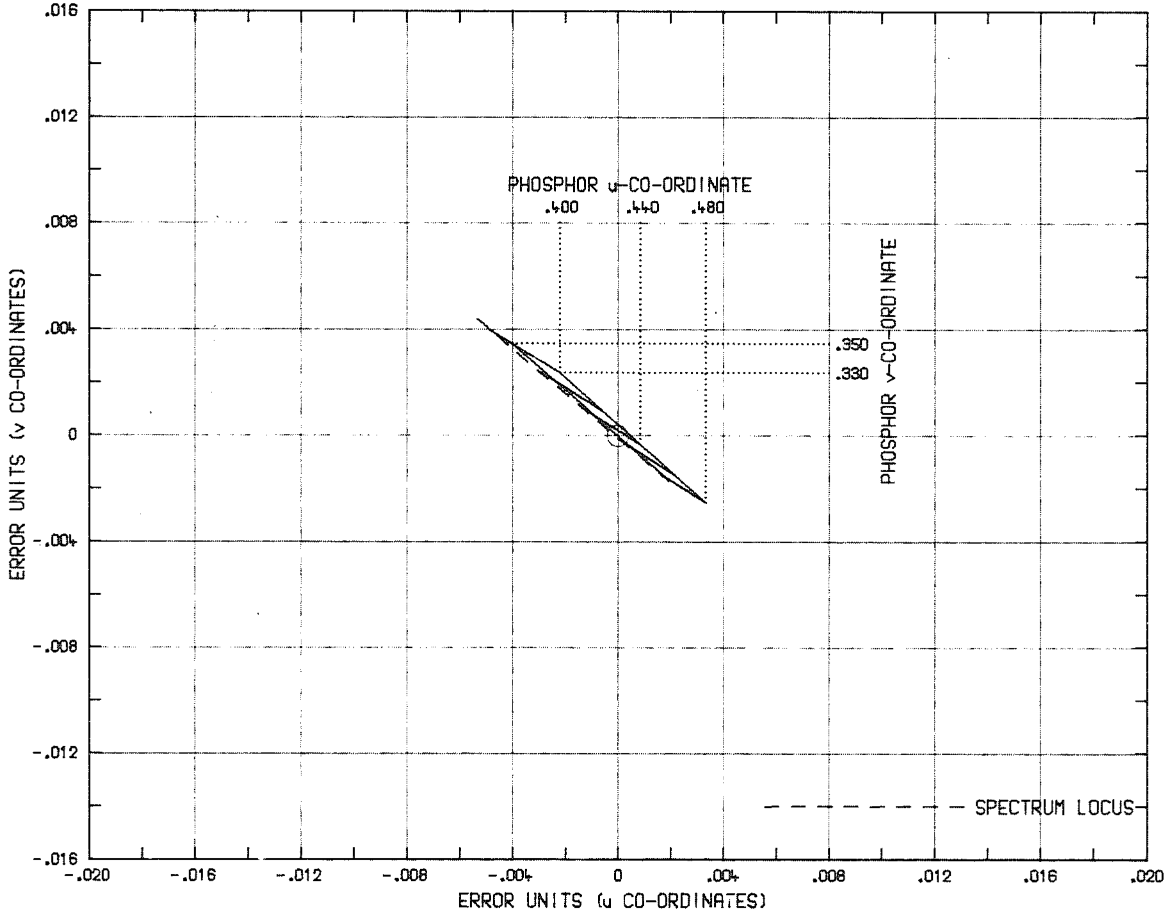
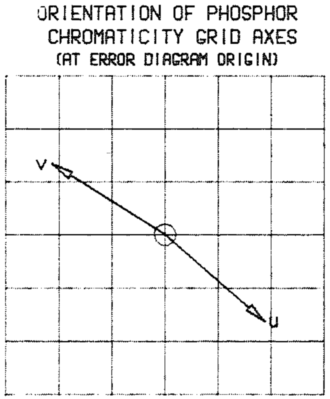


Diagram BBC 16/R
Test Colour BBC 16
Red Phosphor



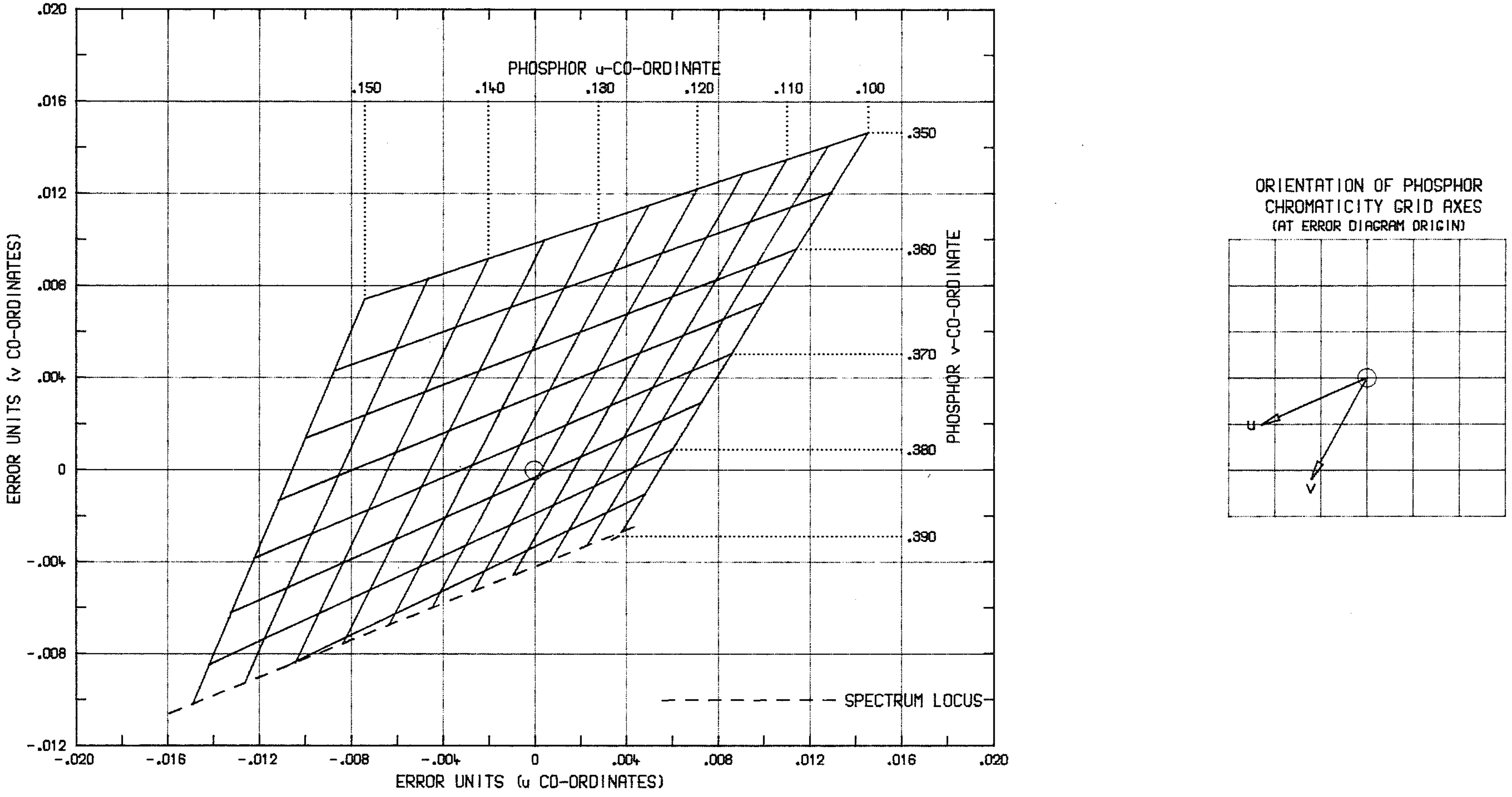
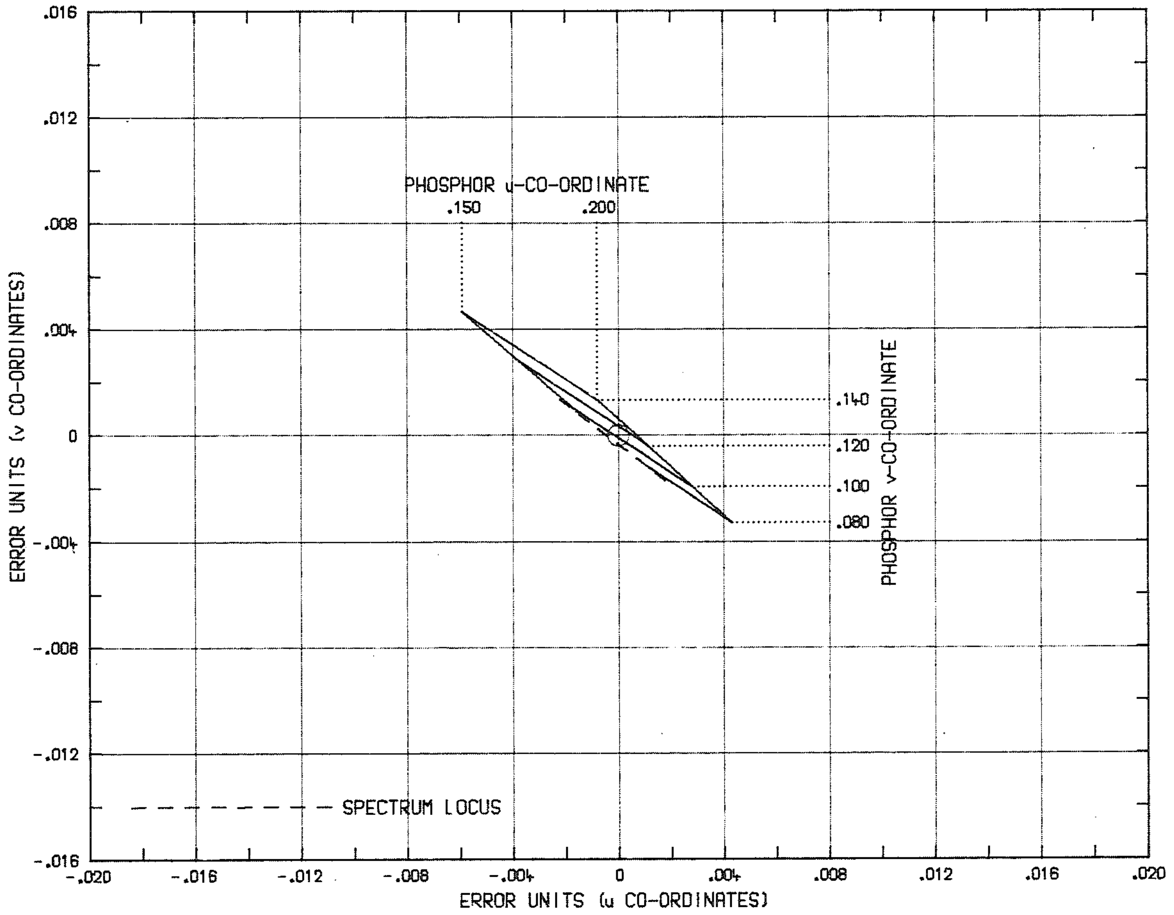


Diagram BBC 16/G
Test Colour BBC 16
Green Phosphor



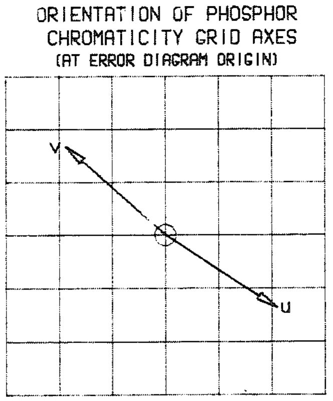
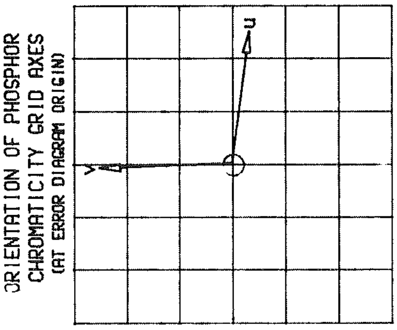


Diagram BBC 16/B
Test Colour BBC 16
Blue Phosphor



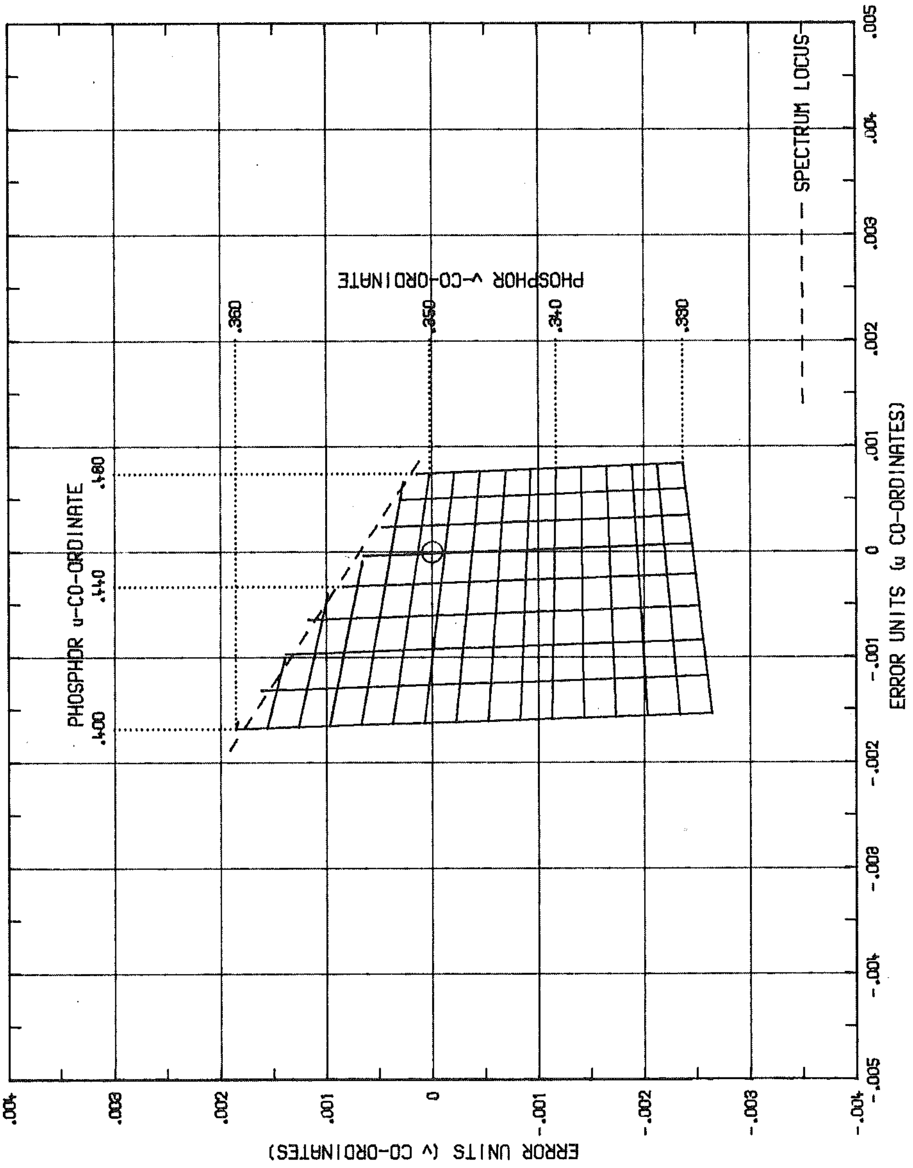
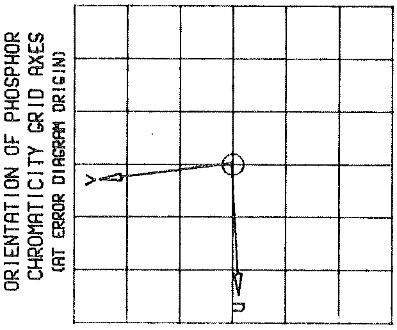


Diagram BBC 17/R
Test Colour BBC 17
Red Phosphor



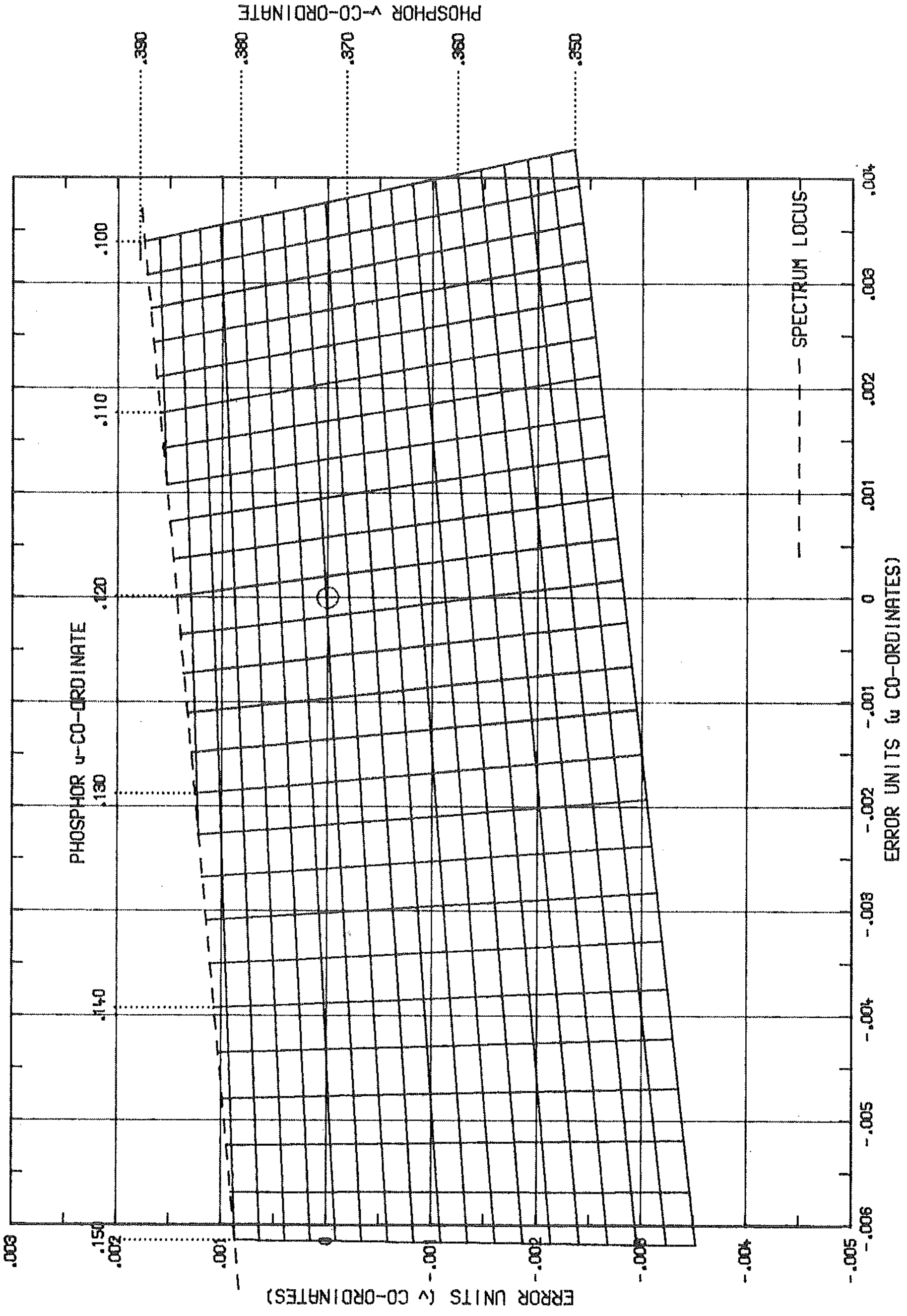


Diagram BBC 17/G
Test Colour BBC 17
Green Phosphor

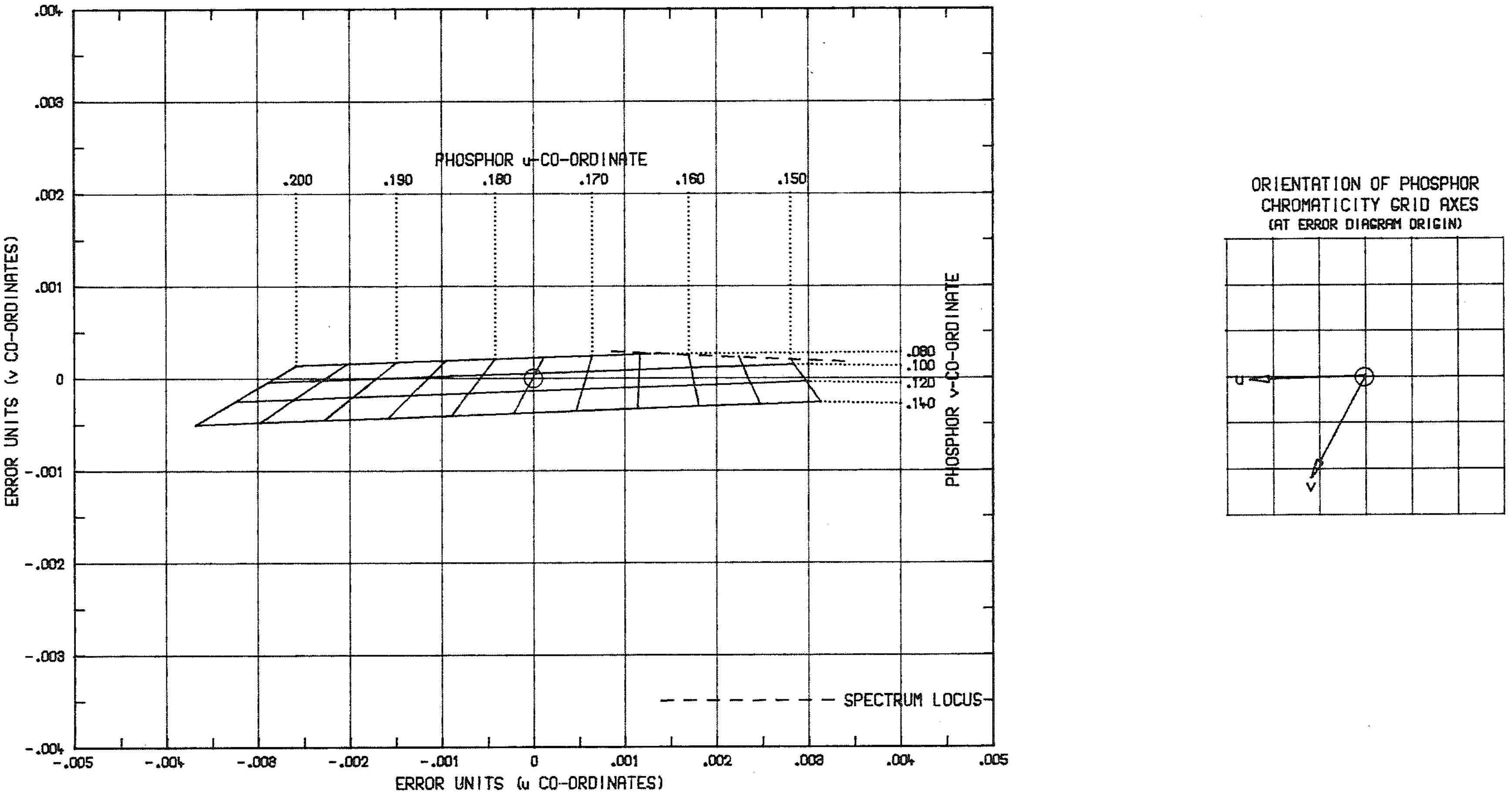


Diagram BBC 17/B
Test Colour BBC 17
Blue Phosphor

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